Air & Space

National Air & Space Museum
Smithsonian Institution

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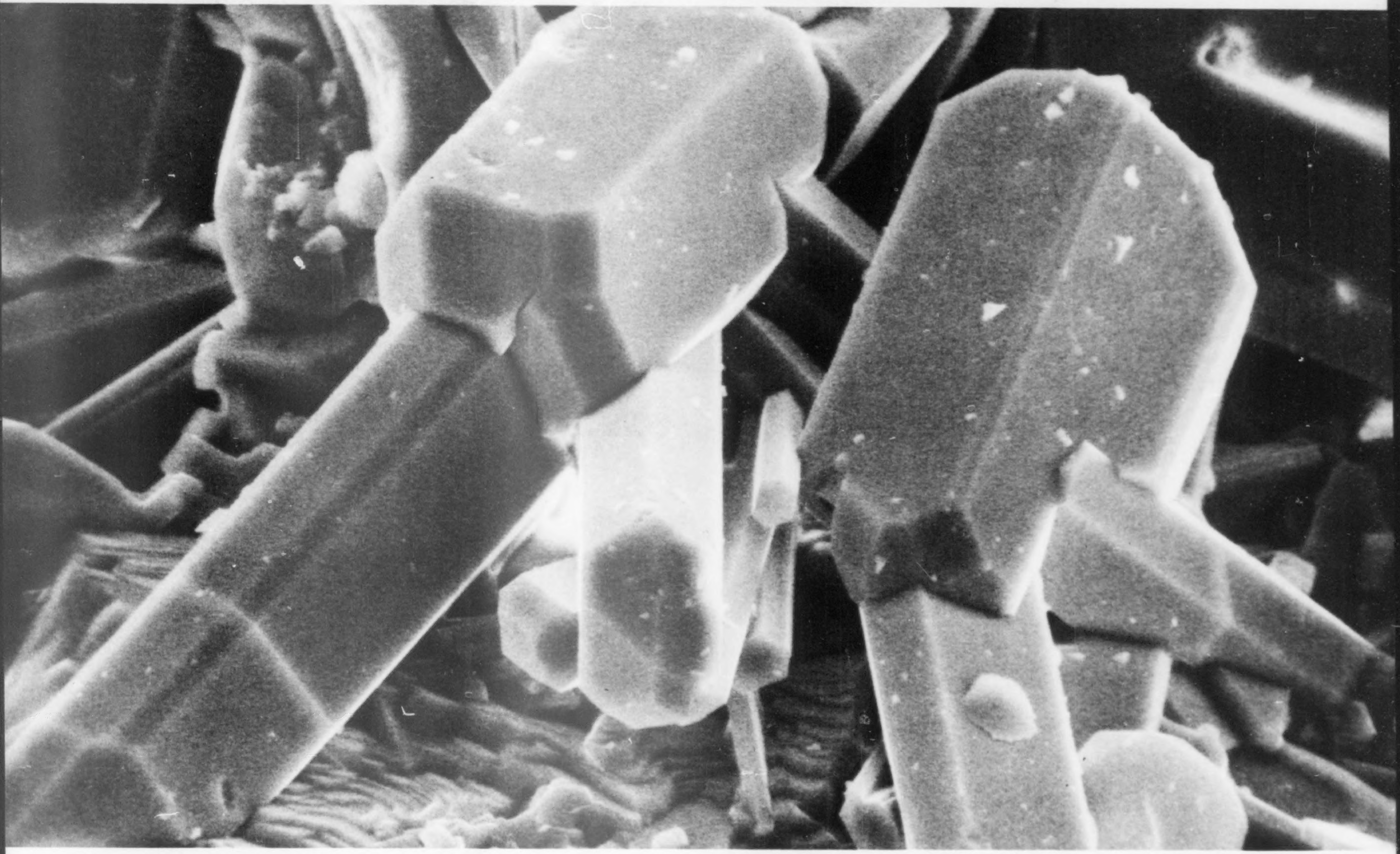

SPACE ROCKS

Looking like an alien landscape, the tiny crystals shown above grew in a lunar rock four billion years ago. Brought to Earth by the Apollo 14 astronauts in 1971, they form part of a rich lode of extraterrestrial material—Moon rocks, meteorites, and bits of cosmic dust—that is providing earthbound scientists with a really close look at the Moon and other bodies in our Solar System.

By bringing "space rocks" into laboratories here on Earth, we have discovered things that no spacecraft or groundbased observations could have told us. We have learned what the Moon is made of—not green cheese, but rocks surprisingly like the rocks of Earth. We have outlined the Moon's strange and violent history, measured the age of the Solar System, and acquired some hint of what happened before it formed. Space rocks have given us actual samples of atoms from the Sun from which we may chart the past—and perhaps the future—of our own personal and necessary star.

The photograph above, taken by a powerful scanning electron microscope, is a view into a tiny crack in a lunar rock. The rock itself was formed when a giant meteoroid struck the Moon. This catastrophic impact shattered and melted the lunar bedrock and formed an unusual fragment-rich rock called a *breccia.* Hot gases produced by the intense heat flowed through cracks in the rock and deposited these tiny, six-sided crystals on the walls of the crack. The crystals, only about .02 millimeter long, are a mineral called *apatite* (a calcium phosphate) that also is found in terrestrial rocks and in teeth and bones. (More, page 3.)——Bevan M. French

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Air & Space, a mini-magazine for educators, is published four times during the year, September through May, as an outreach of the National Air and Space Museum, Smithsonian Institution, Washington, D.C.

Air & Space combines information from many sources for a condensed overview of the history, science, technology, and social impact of selected aviation and space subjects.

Air & Space *Registration*

Current recipients of *Air & Space* must fill out the blue circulation card bound into this issue and return it by October 10, 1980 to *Air & Space*, Room P700, Education Services Division, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560.

For changes or corrections of address, write the correct address in the appropriate place on the card. Readers receiving unwanted duplicates should return only one renewal card.

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Air & Space may be freely photocopied for classroom use. Commercial interests and other publications wishing to reprint material should mail request (address on back cover).

MUSEUM HOURS

Until Labor Day (September 1), the Museum will be open from 10 a.m. to 9 p.m.; starting September 2, Museum hours will be 10 a.m. to 5:30 p.m. The Museum is open to the public every day of the year except Christmas.

For brevity, the National Air and Space Museum is often referred to in these pages as NASM. The National Aeronautics and Space Administration is NASA.

BRIEFING

Noel W. Hinners
Director, NASM

Many of you are aware that during the past year we have been taking a critical look at *Air & Space* magazine. The examination was triggered in large measure by the fact that the costs of producing the magazine were escalating—partly because of the very success of the publication—thus creating an undue drain on our trust fund budget (*Air & Space* is *not* funded by federal appropriations!). Our review of the magazine also was prompted by my own doubts about the objectives and effectiveness of *Air & Space*. (After all, it's easy to give things away for free.)

As a temporary budgetary measure, we had closed the registration list for *Air & Space* on May 30, 1979, maintaining circulation at about 30,000. Under the able guidance of Janet K. Wolfe, Unit Chief for Outreach Programs in our Education Services Division, we sampled our readership last winter to determine who receives *Air & Space*, how they use it, what they like about it, and if they would be willing to pay for a subscription. Your response, an incredible 45 percent of almost 5000 polled, was, frankly, more vigorous and informative than I anticipated and has converted me from a doubter into an *Air & Space* advocate.

More than half of the responses we received were from individual teachers, the rest coming from a mix of administrators, librarians, staff, and private individuals and companies. Sixty-five percent of you read most or all of the articles in each issue, and 68 percent pass *Air & Space* on to a broader audience of students, libraries, and colleagues. You tend to prefer articles on space science, aerospace concepts and technology, and the historical period from 1946 to the present. A large number of you find the charts, diagrams, games, and other student activities in *Air & Space* very useful as teaching aids. About half of you would be willing to pay $1.00 per issue, but only about half of the schools would foot the bill.

Where does all this leave us? With a renewed commitment to *Air & Space* as a key outreach of the National Air and Space Museum. I'm now convinced that we have a good product that is reaching the right audience and that we should continue to provide. We have concluded that instituting paid subscriptions—at a price that would make *Air & Space* pay for itself—would cause an undesirable number of dropouts from our targeted audience. So we will continue to fund *Air & Space* ourselves, but must cut some costs. This includes eliminating expensive foreign mailings, and publishing four issues per year instead of five. Because of the economies of publishing fewer issues per year, we have determined that we can afford to maintain the total pages per year at 80, giving you four issues of 20 pages each, rather than five 16-page issues. The additional pages per issue also will provide our authors the extra page or two that many articles warrant. We intend to hold circulation at 30,000 but annually will purge the disinterested from the rolls to make room for new subscribers. It is *your* responsibility to respond positively by returning the enclosed card if you want to continue to receive *Air & Space*.

I'm delighted to find how alive you are "out there." Keep in touch with us—write to Jan W. Steenblik, Editor, with your thoughts and constructive criticisms. We are here to provide a service.

REGISTRATION RENEWAL for complimentary mailing of *Air & Space*, a mini-magazine for educators

Air & Space Magazine will continue to be available at no charge to educators who are currently registered. If you wish to continue receiving *Air & Space* Magazine, please fill in your *code number* from your mailing label in the boxes below. Your card must be received at NASM by October 10, 1980 to continue your registration.

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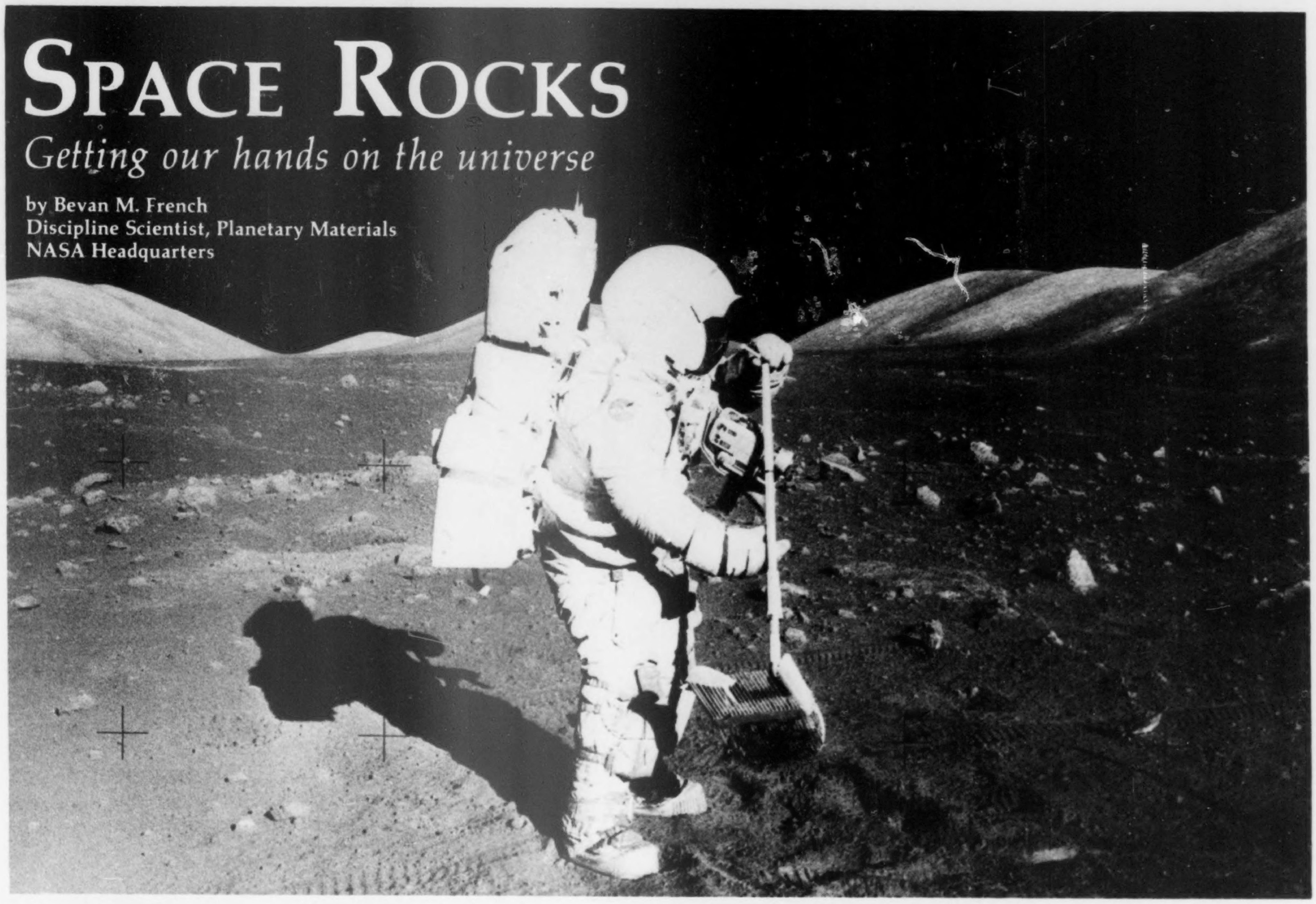
SPACE ROCKS

Getting our hands on the universe

by Bevan M. French
Discipline Scientist, Planetary Materials
NASA Headquarters



We can now hold the Moon in our hands. Above, Apollo 17 astronaut Harrison ("Jack") Schmitt rakes up samples of lunar rocks and soil (some of which have actually trapped atoms from the Sun) from the floor of the Moon's Littrow Valley in December 1972.

Above: Two awestruck visitors to the National Air and Space Museum gingerly touch an actual Moon rock—a slice of lunar basalt—brought to Earth by the Apollo 17 astronauts. Samples of other types of lunar rocks and soil are on display in NASM's Apollo to the Moon gallery.

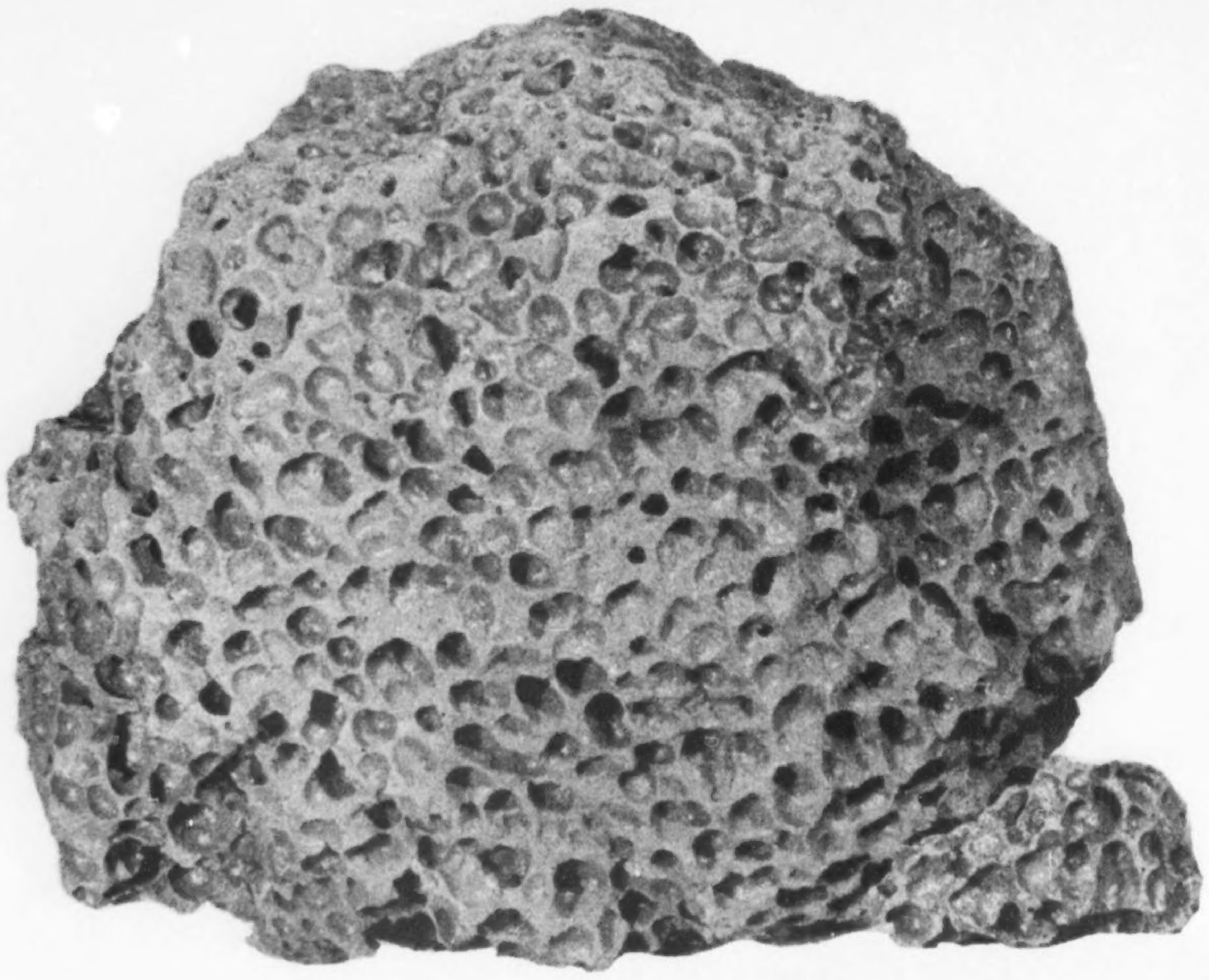
Today we can do more than just look at other worlds—we can touch them. By reaching out into space, we have actually grabbed pieces of the universe and brought them back to Earth. Hundreds of scientists in terrestrial laboratories are now exploring the Solar System by studying space rocks—samples brought back from the Moon, and metorites that fall to Earth.

Are space rocks important? Yes, indeed. No matter how many stunning pictures and exotic measurements we get from spacecraft, we still need actual rocks to tell us what any world is really like. Once we have rocks, we can measure their composition exactly, analyzing more than 80 elements from aluminum to zirconium. This gives us a very good idea of the composition of the planet or moon as a whole. Knowing the physical properties of rocks—their magnetism, strength, and heat conductivity—is critical for interpreting the data that our instruments send us. Rocks are planetary clocks—they preserve evidence of when they formed, and they help us decipher the history of other worlds. Rocks are "space probes"—they trap matter and energy from the universe and give us a record of what our cosmic surroundings are like.

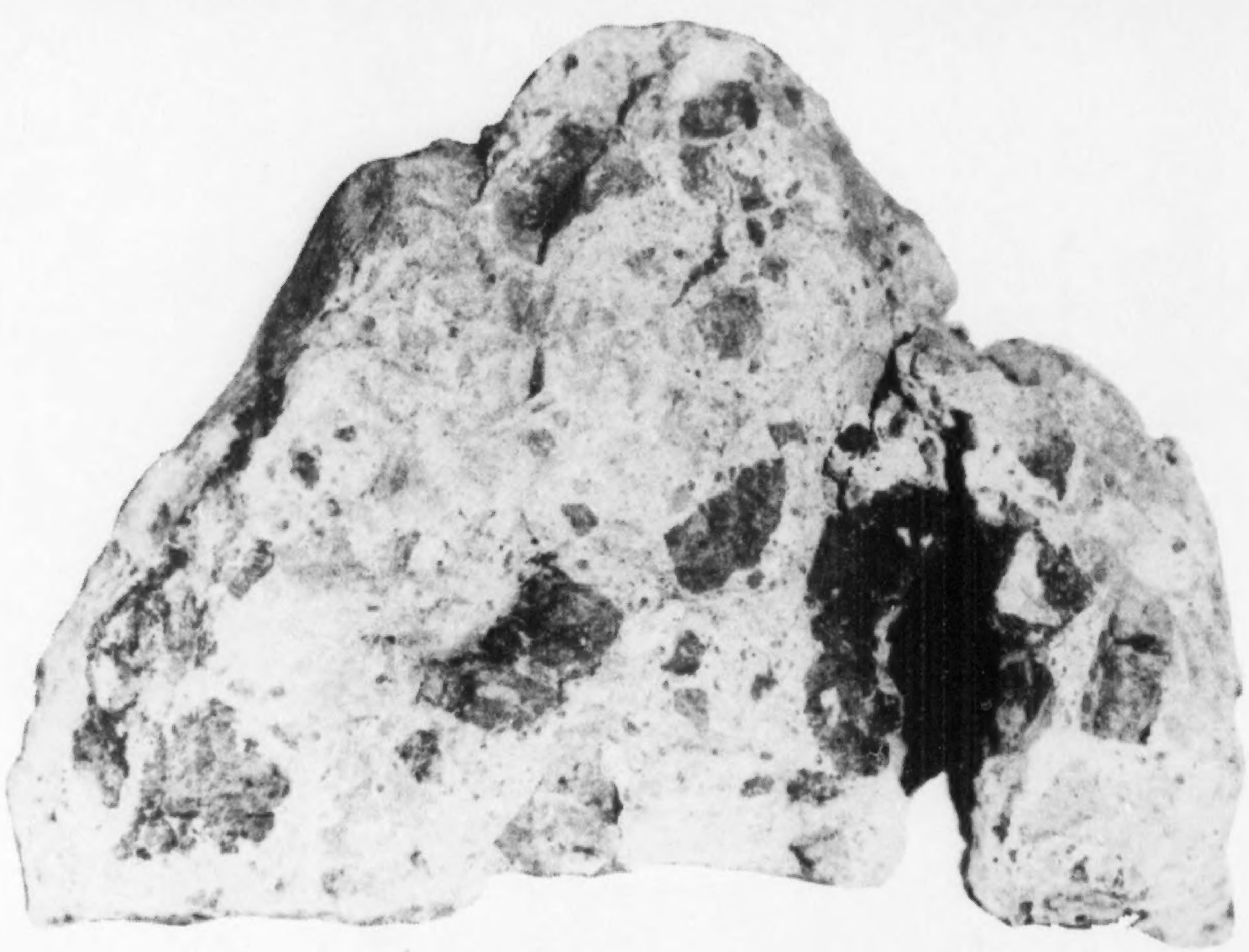
The Moon: A World of Its Own

We now know that the Moon is a unique world, with a complex history—sometimes violent, sometimes quiet. This history has produced several types of rocks. The rugged, light-colored lunar regions (called *terrae* or *highlands*) are made up of ancient lunar surface rocks (mainly *anorthosite*, a calcium-rich white rock) that cooled slowly from a primordial ocean of molten lava as the Moon itself was forming 4½ billion years ago. The dark regions (called *maria*, or "seas") are younger, a mere 3½ billion years old. They are made up of dark-colored lavas *(basalts)* that erupted from great cracks in the Moon and poured across its surface. There are also fragmental rocks *(breccias)* formed as the lunar crust was shattered by huge meteoroid impacts more than 4

Related Flight series filmstrips: *Apollo to the Moon* and *Great Spacecraft and their Accomplishments* (see Outreach, page 19).



Lava from an ancient lunar volcano, this Apollo 15 specimen (above) is typical of the dark material that covers the low, level lunar maria *or "seas." The bubbles were formed by gas escaping from the molten, rapidly cooling rocks. But the rock contains no water, and the nature of the bubbling gas remains a mystery.*



Above: Like a cosmic jigsaw puzzle, this white rock (a breccia*) from the lunar highlands contains pieces of many different broken lunar rocks—black, white, and gray—all jumbled together. Produced by a catastrophic meteorite impact about 4 billion years ago, the rock was collected by Apollo 16 astronauts near the crater Descartes.*

billion years ago. Over everything is the layer of lunar "soil." This is a black, powdery, lifeless material formed by the slow breaking up of bedrock by recent impacts of tiny meteoroids. Lunar soil is a bulk sample of the Moon and a trap for the atoms sprayed out into space by the Sun.

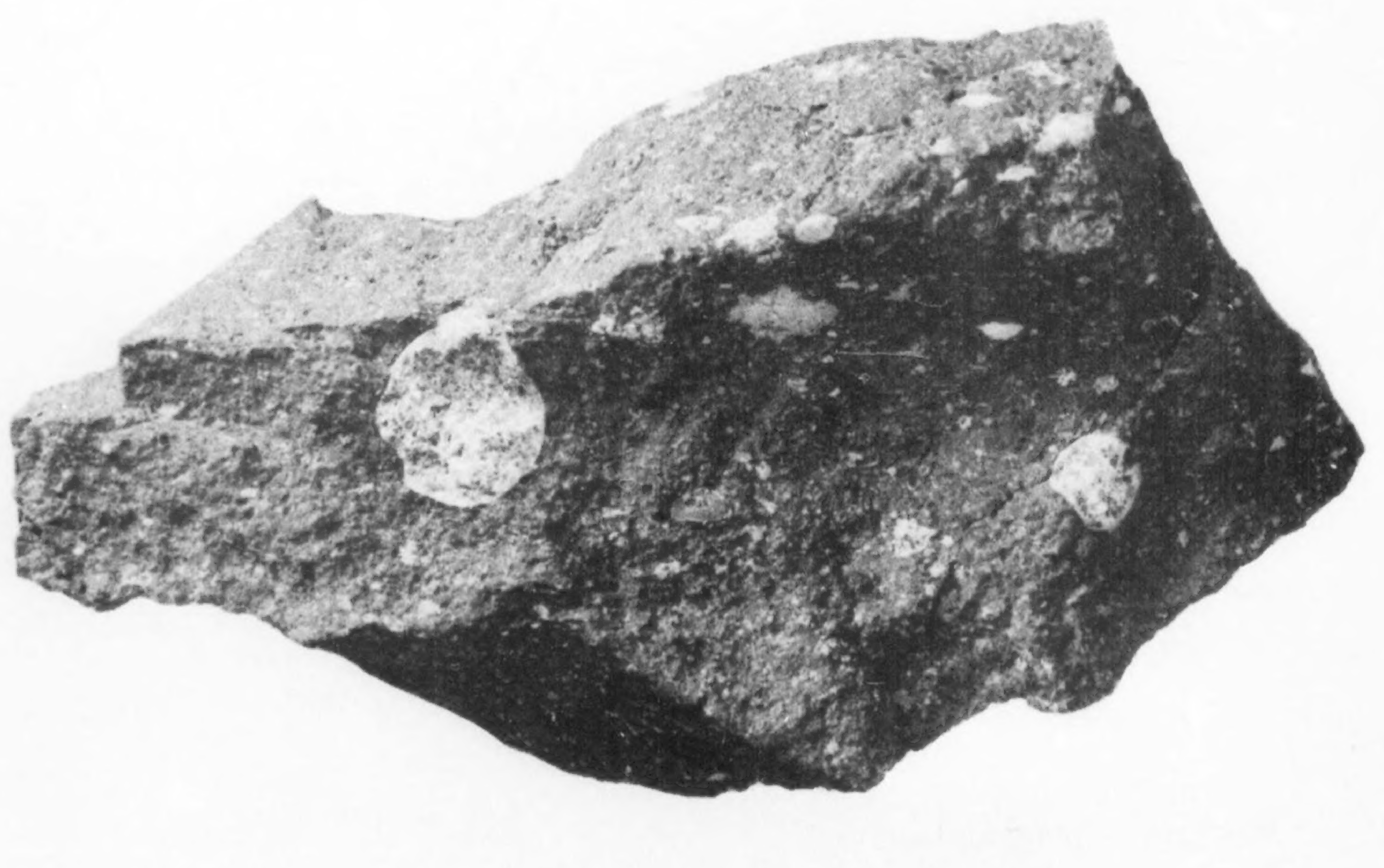
The Moon rocks are much like Earth rocks—a somewhat surprising discovery because the two worlds are so different. Moon rocks contain the same chemical elements as Earth rocks and are made up mostly of the same minerals. (Only three rare new minerals have been found on the Moon.) But the Moon rocks contain no life and no water. Their crystals, untouched by water-produced rust and clay, are fresh and clear, even though they may be more than 4 billion years old.

Meteorites: Back to the Beginning —and Before

Meteorites have been known, both as curiosities and as space specimens, for centuries. They come from farther away than the Moon—probably from the Asteroid Belt between Mars and Jupiter, but we don't know exactly where. They are the oldest space rocks we know of, formed 4.6 billion years ago during the formation of the Solar System and preserved in the "deep freeze" of outer space ever since.

Meteorites show us the different kinds of matter that the Solar System has to offer. Some meteorites are huge chunks of natural iron-nickel alloy. Others are mixtures of iron metal and rock. Some look like the volcanic rocks (basalts) that we brought back from the Moon. Most meteorites are stony, and are made up of millions of tiny beads of glass and crystals. A few consist of rock fragments; these very much resemble the lunar breccias.

Meteorite research is especially exciting just now, because scientists are looking at meteorites with the instruments and insights developed from a decade of studying lunar rocks. Some white rock fragments from a meteorite that fell in Mexico in 1969 have provided one of the most exciting surprises—traces of chemical matter that may have been blasted out of a nearby star, an exploding supernova, before the Solar System had even formed. Some scientists think that the supernova actually may have triggered the formation of the Solar System itself and everything in it—including us.



Left: A recent arrival from the Asteroid Belt, this carbon-rich meteorite fell on the small town of Allende, Mexico in February 1969. Some of the white inclusions contain traces of matter produced in other stars before our Solar System formed.

Space Rocks and the Future

No matter what missions we fly into space in the future, the rocks from space will provide new discoveries for years to come. Many lunar breccias wait, like cosmic jigsaw puzzles, to provide us with a better picture of the ancient Moon. Core tubes full of lunar soil remain to be opened and examined; they may tell us the history of the Moon and the Sun for 1½ billion years into the past. Long-stored meteorites in many museums are waiting to reveal their secrets to new instruments and new scientists.

Even without leaving the Earth, we are still collecting more material from space. Thousands of well-preserved meteorites have been recovered from the frozen Antarctic ice cap, and more thousands remain to be found. Tiny bits of meteorites are being salvaged from the ancient muds on the bottom of the seas. High-flying aircraft recently have trapped tiny dust particles that may be our first samples of the comets that zoom past the Earth.

Without space rocks, our yield from space exploration would be poor indeed. We would still be arguing about what the Moon was made of and how old it is. We would have no idea about when the Solar System formed, how fast it formed, or what happened before it formed. We might never have a chance to decipher the history of the Sun. In the future, when the long-debated question about life on Mars is finally resolved, the answer may come from Earth—from the laboratories where scientists study bits of Martian rock and soil that will be brought back by robot spacecraft or by human beings.

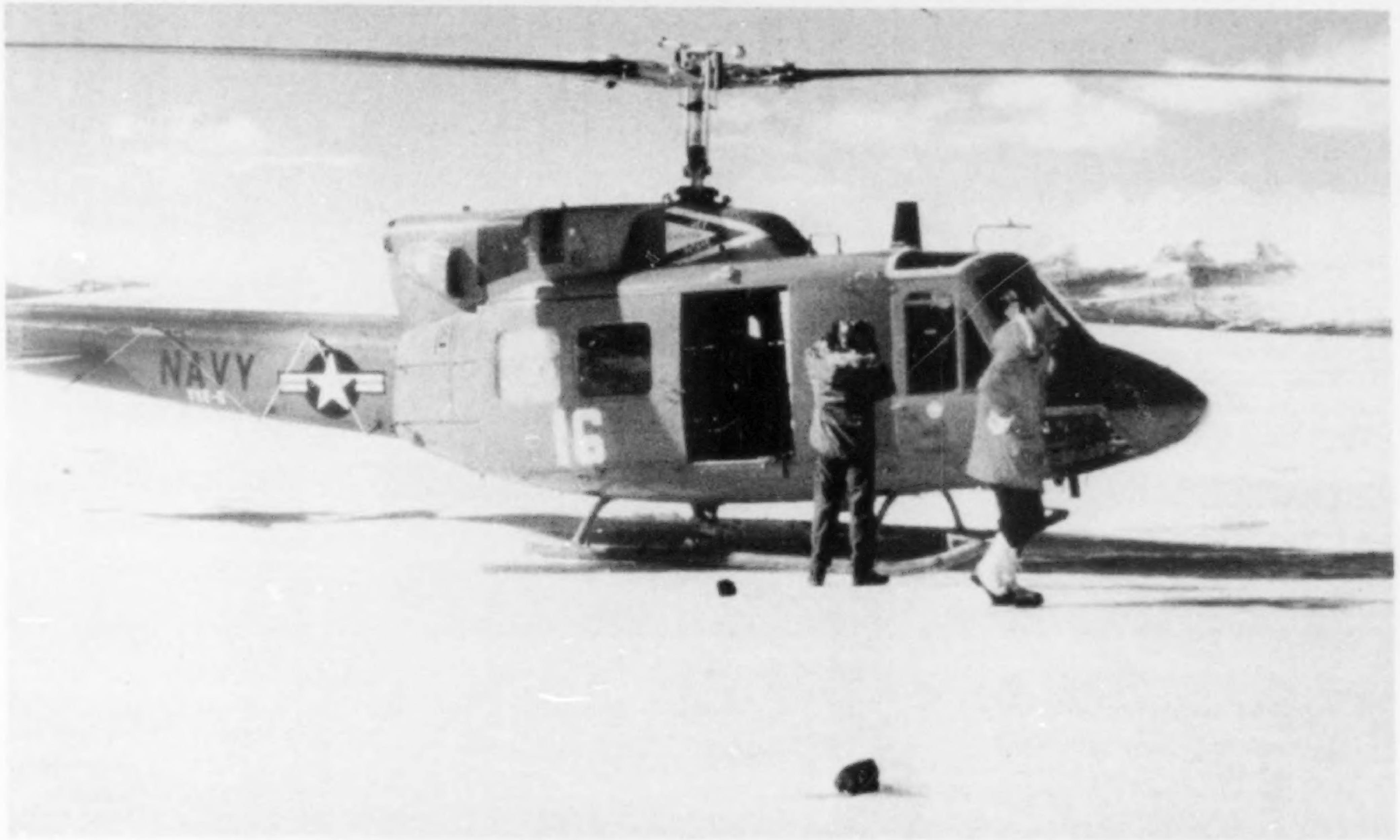
Readings

The Moon Book, Bevan M. French. New York: Penguin, 1977.

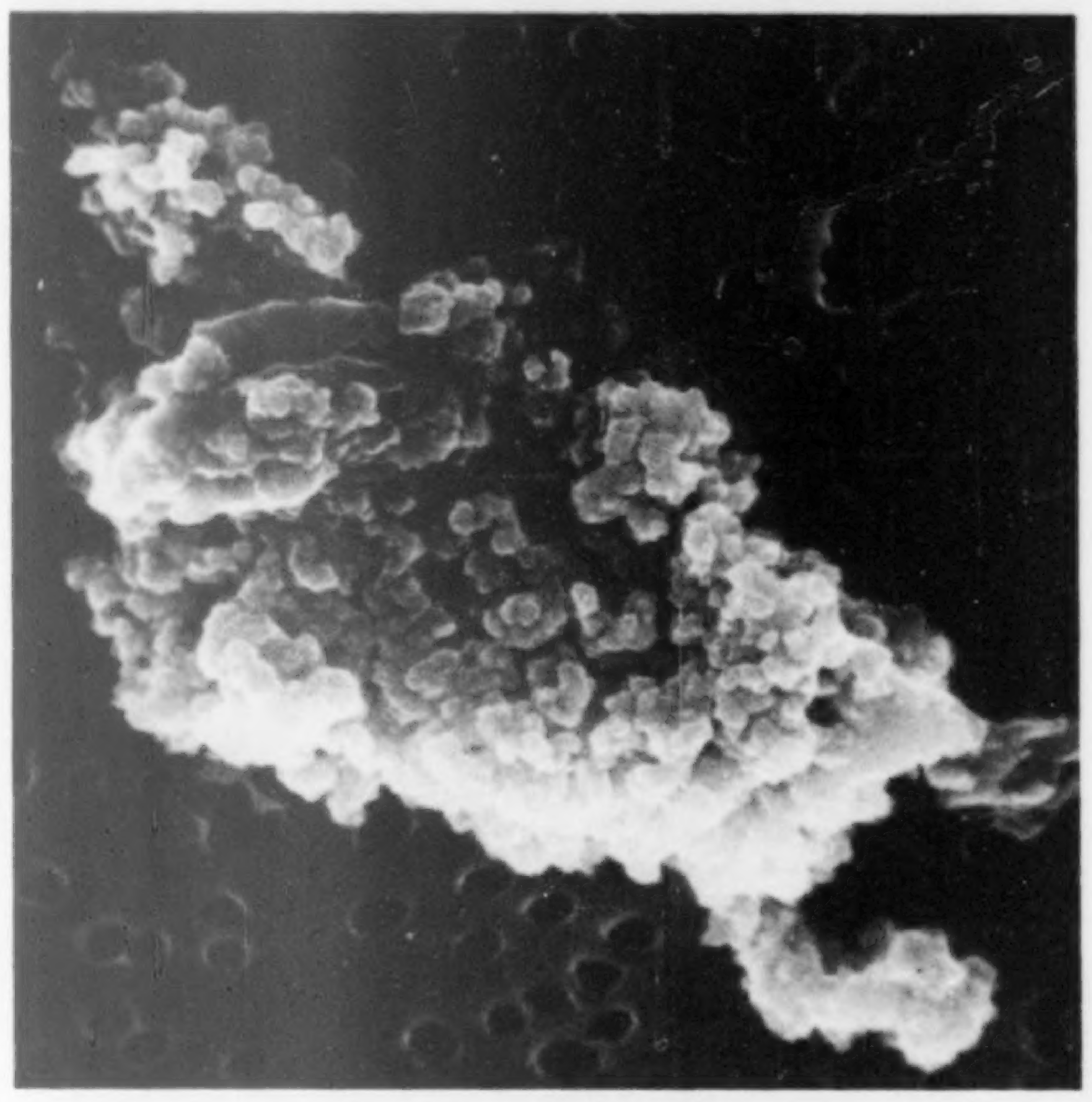
A Close Look at the Moon, G. J. Taylor. New York: Dodd, Mead, and Company, 1980.

Meteorites: Stones from the Sky, R. V. Fodor. New York: Dodd, Mead, and Company, 1976.

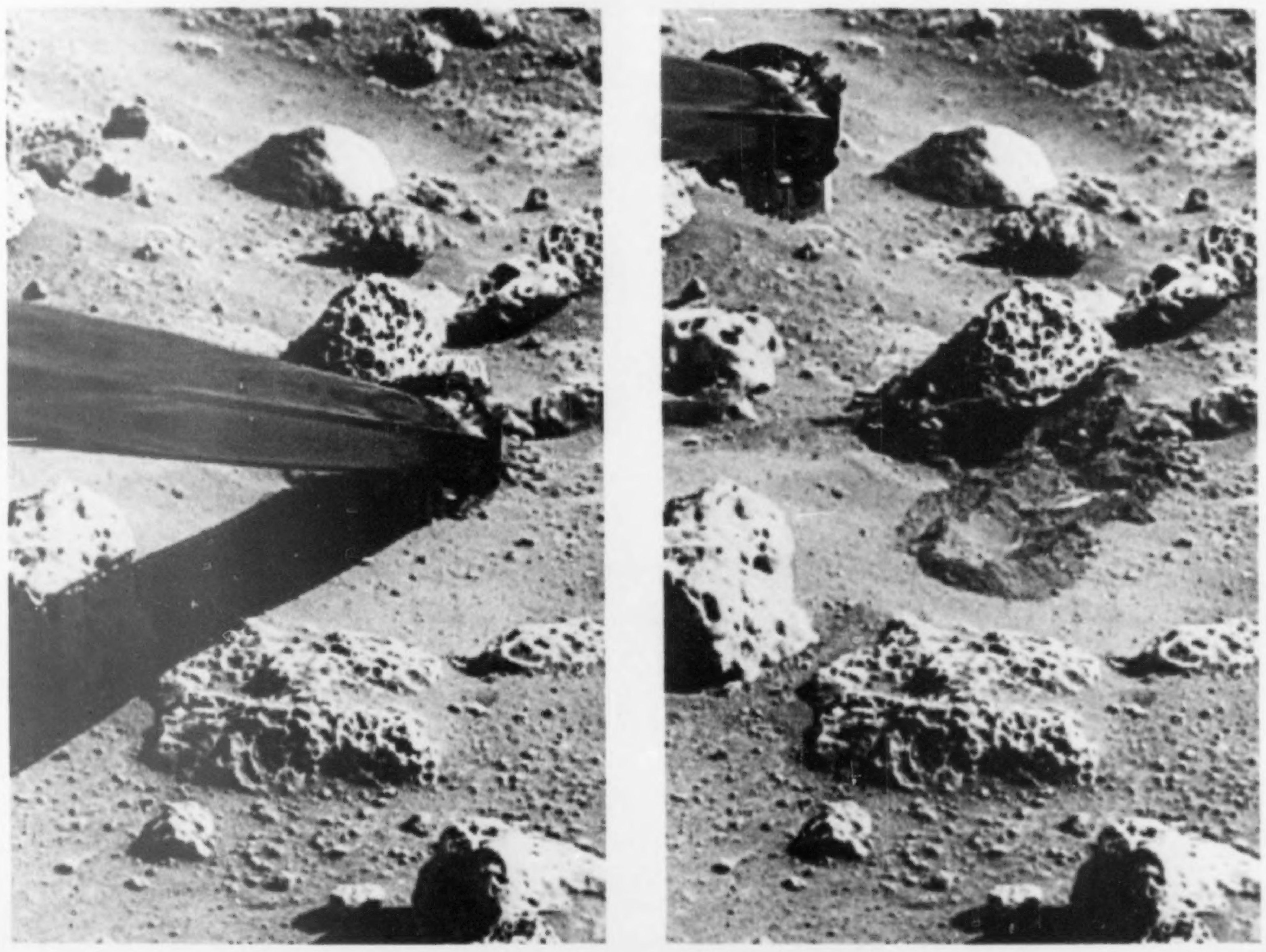
Out of the Sky: An Introduction to Meteorites. New York: Dover, 1952.



Above: The Antarctic ice cap is now yielding a treasure trove of thousands of well-preserved meteorites, some of which have been carried in the slowly moving polar ice for hundreds of thousands of years. Three meteorites are shown here: one in the foreground, one by the helicopter door, and one in the distant left center under the helicopter's tail.



Left: A piece of a comet? A tiny piece of interplanetary dust, less than .01 millimeter long, is made up of millions of tiny crystals. Collected by a high-flying U-2 aircraft, particles like this one have a chemical composition similar to that of meteorites and actually contain trapped atoms from the Sun.

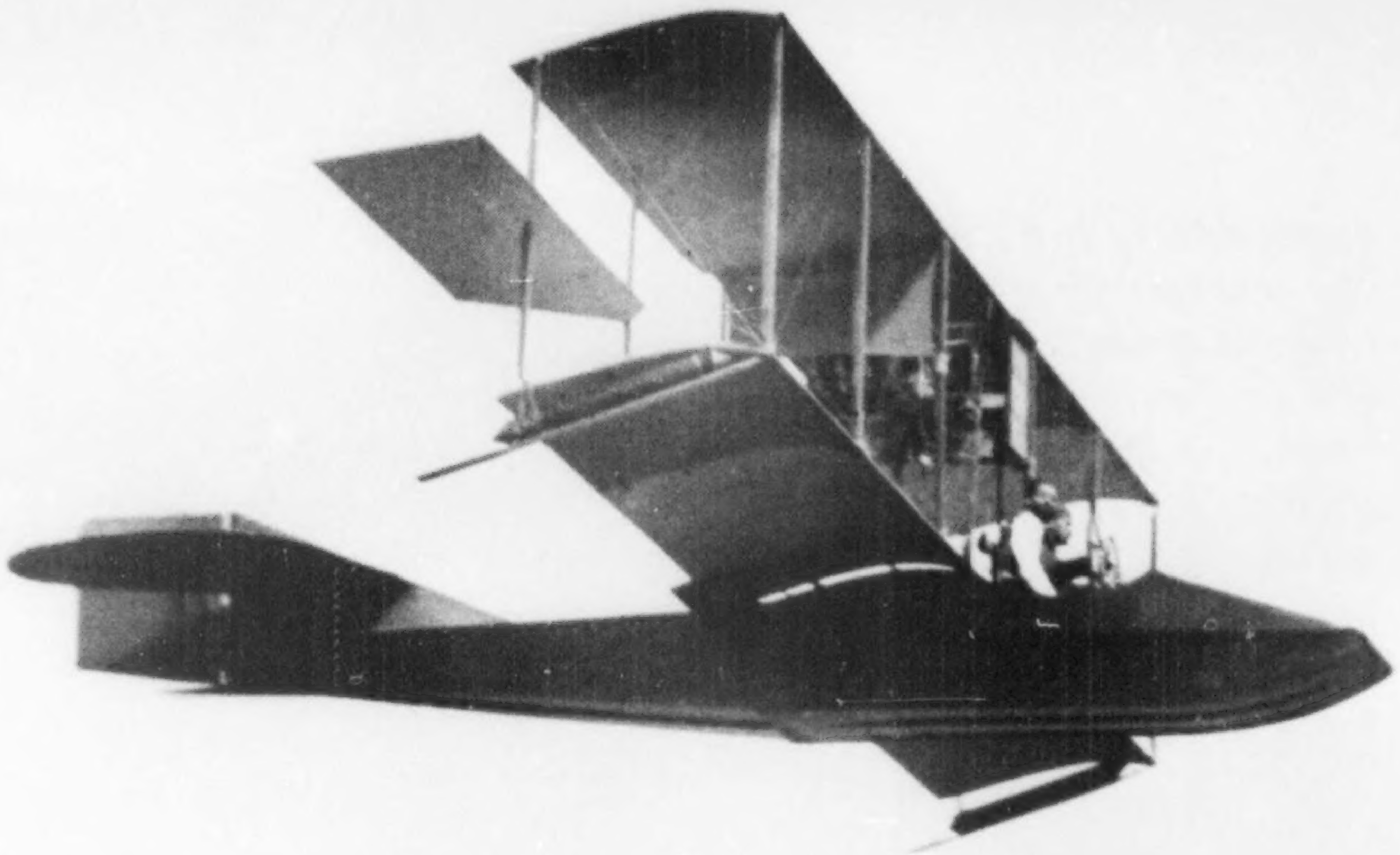


Right: Just out of reach—for the moment—the rocks of Mars, photographed by the Viking lander spacecraft, still await collection and study. The rocks at this Martian site resemble the bubble-rich volcanic lavas collected from the Moon. In these two pictures, the Viking 2 sampling arm pushes a rock aside to collect a sample of the finer soil beneath it.

FLYING BOATS

helped build today's ocean-spanning air transportation network

by Louis S. Casey
Museum Specialist
Department of Aeronautics, NASM



The 1915 Benoist E-Boat (above) was similar to the Benoist XIV flying boat used in 1914 by the world's first scheduled airline, the St. Petersburg-Tampa Airboat Line.

The practice of flying from water began not long after the invention of the airplane. On March 28, 1910, Henri Fabre of France made four short flights from the harbor of La Mède, near Marseilles, in his *Hydravion* floatplane. These were the first recorded flights from water. However, Fabre failed to exploit the accomplishment; aviation pioneer Glenn H. Curtiss of Hammondsport, New York was the first to overcome the obstacles to making water flying practical and commercially successful.

Curtiss made the first flights from water in the United States on January 26, 1911, piloting his "hydroaeroplane" or floatplane from San Diego Bay, California. On January 10 of the following year, he managed one takeoff from the Bay in a flying boat—the world's first. (A flying boat is an airplane with a hull incorporated as part of its fuselage for water landings and takeoffs.)

Curtiss' Big Step

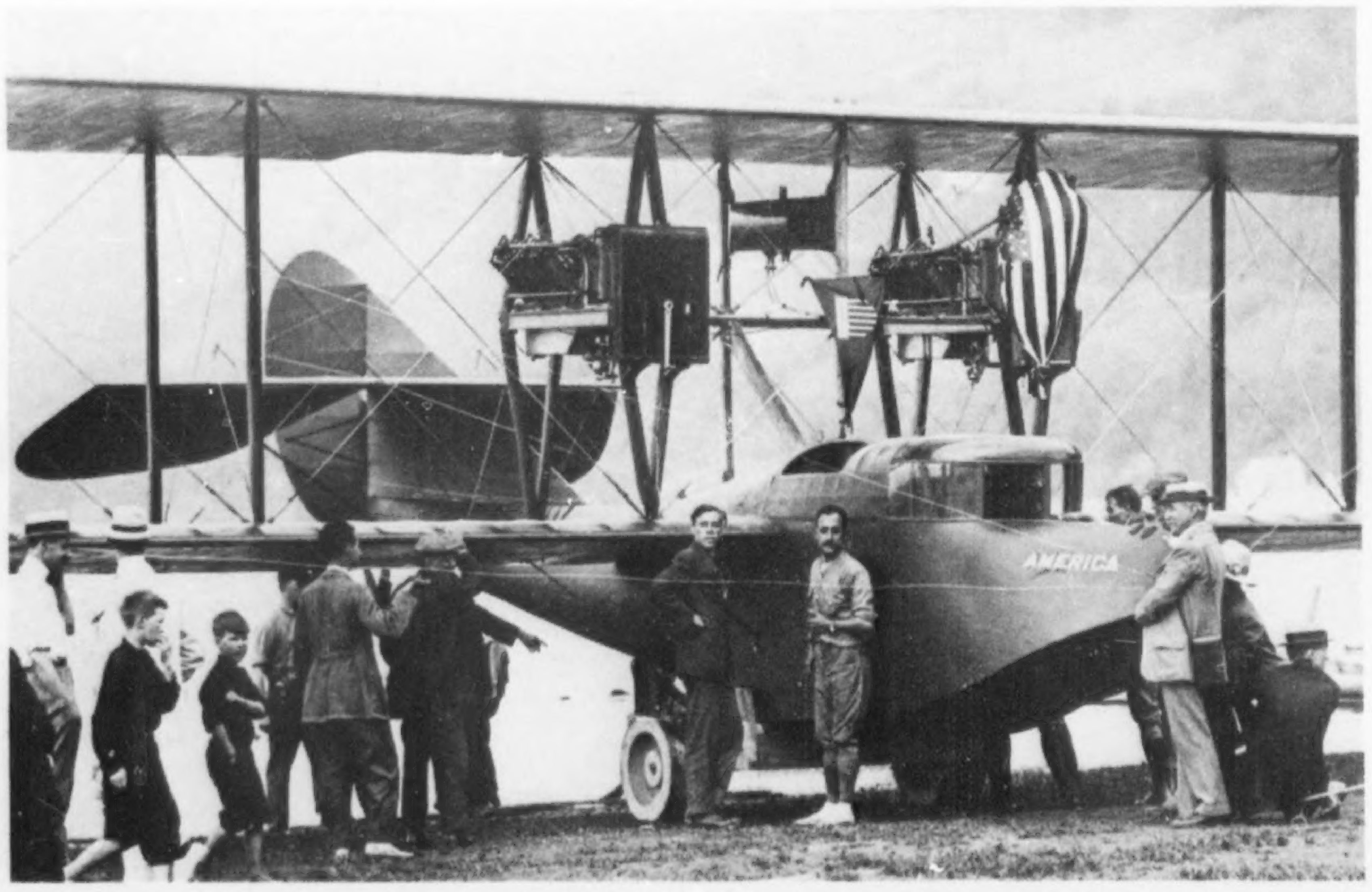
But Curtiss' first flying boat had been extremely reluctant to take off. Its flat-bottomed hull created a strong surface suction as it moved through the water. In the spring of 1912, Curtiss designed a crude "step" in the hull that broke the surface suction and allowed the flying boat to take off. All subsequent flying boats and floatplanes have used this invention.

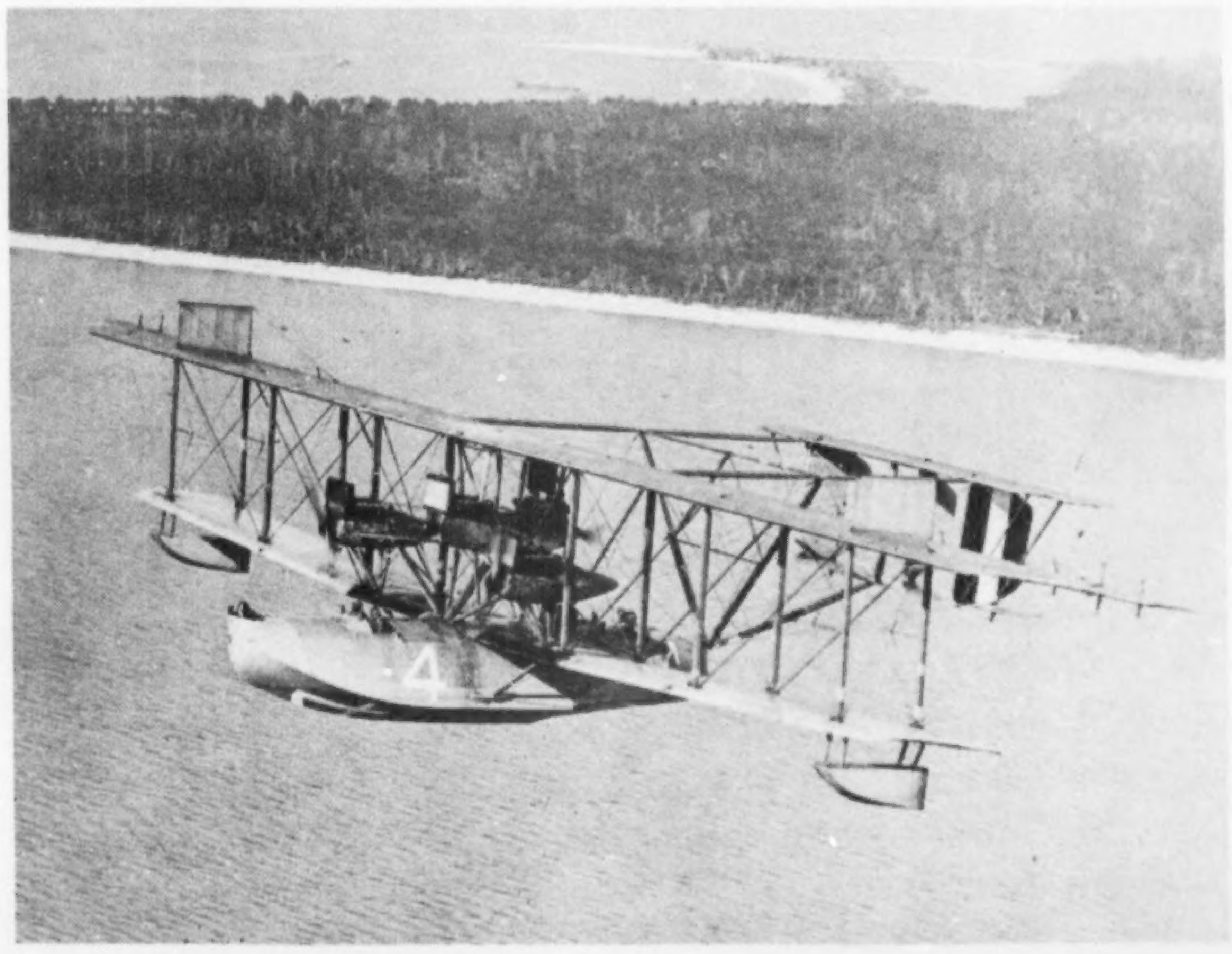
First Transatlantic Flight

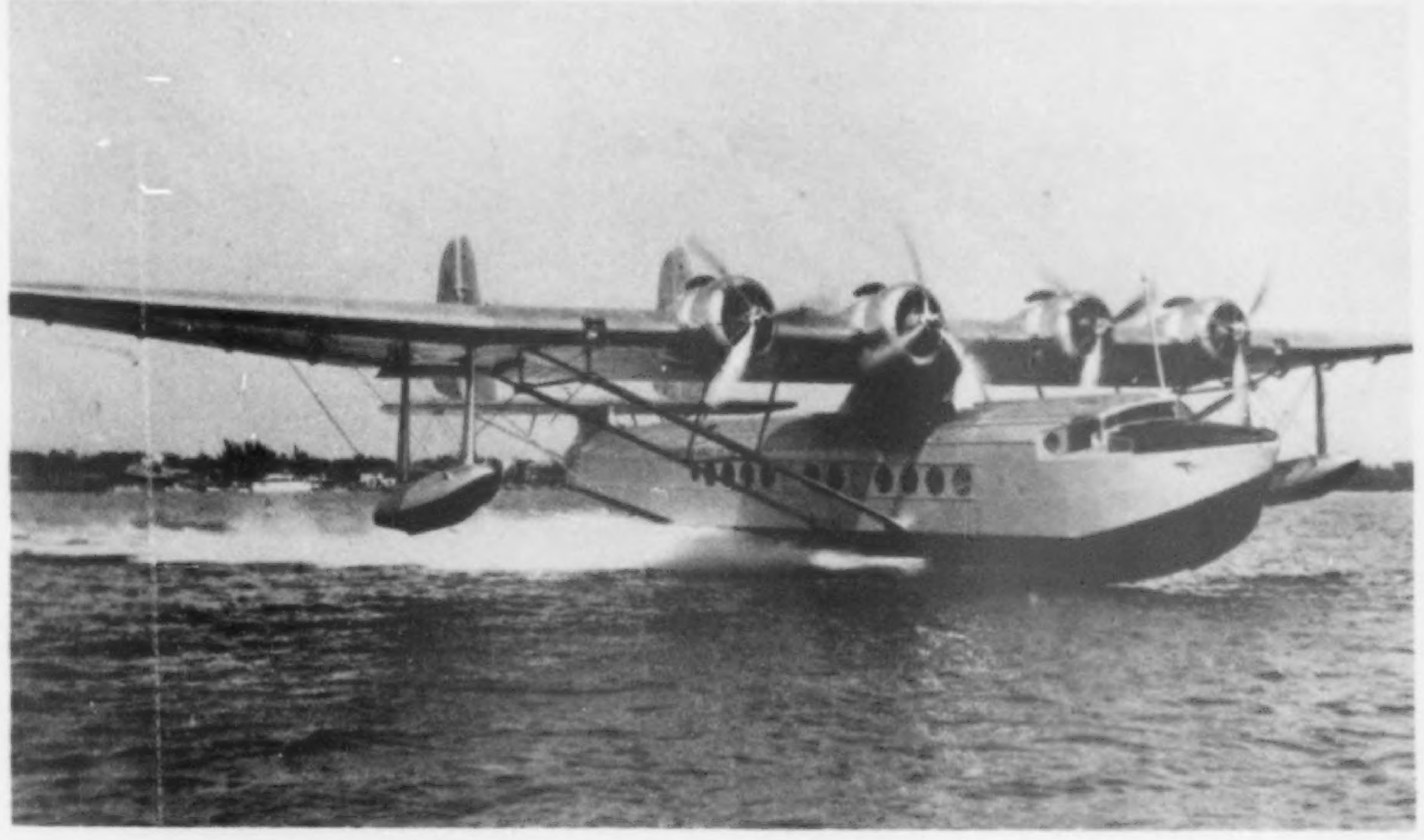
In 1914, Curtiss designed and built the flying boat *America*, the first heavier-than-air craft designed specifically for a transatlantic flight. But the joint U.S.-British transatlantic attempt, intended to promote international friendship, ironically was cancelled by the outbreak of World War I. Modified versions of the *America* were used by the British for antisubmarine patrols of the English Channel.

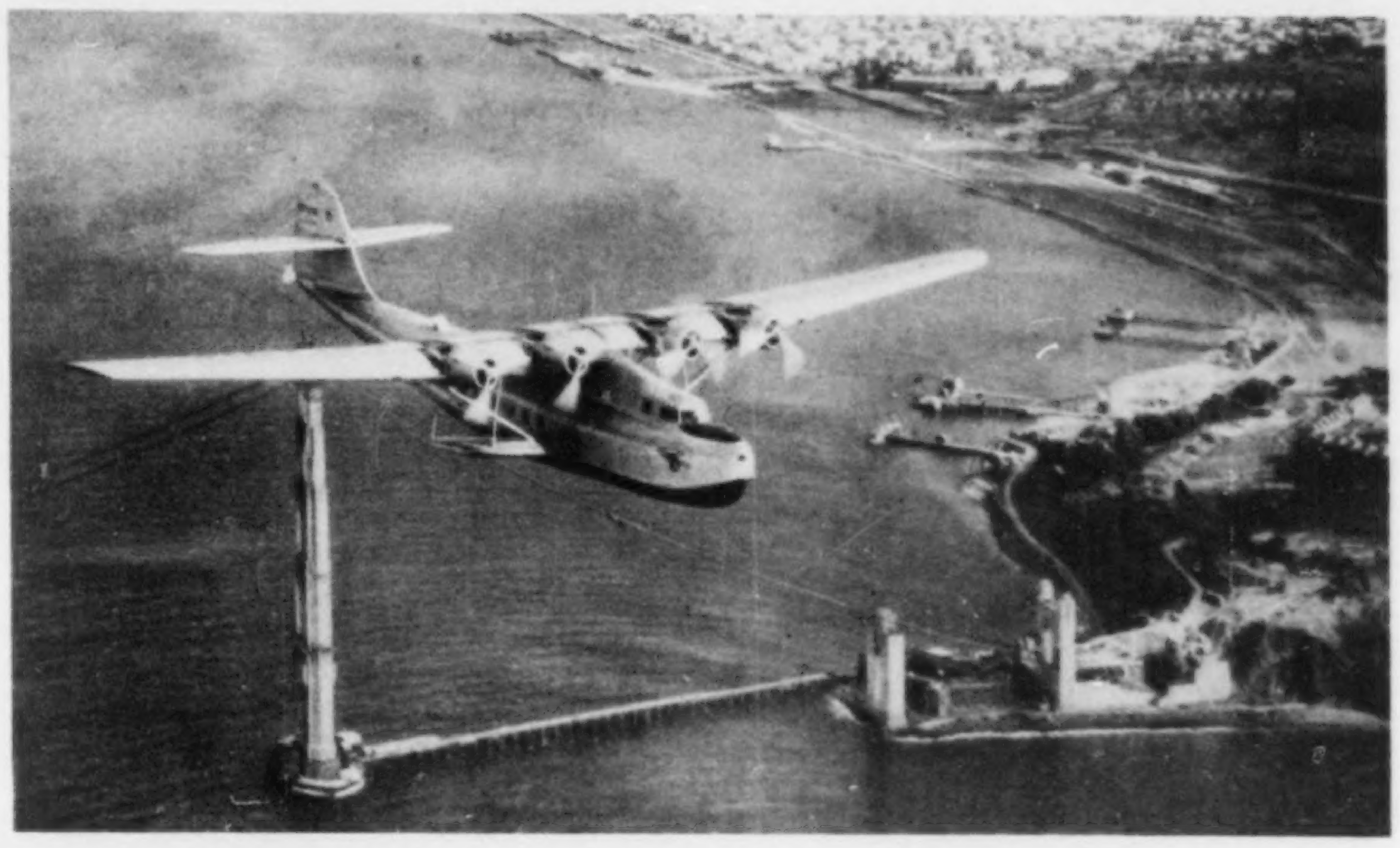
The aircraft that finally succeeded in making the first transatlantic crossing by air had been designed for antisubmarine patrol but was never so used because World War I ended. The U.S. Navy Curtiss NC-4, flown by a crew of six, left Rockaway Beach, New York, on May 8, 1919, and arrived in Plymouth, England, 23 days later after several stops, including Newfoundland, the Azores, and Portugal.

Below left: Glenn Curtiss built the America *in 1914 for department-store magnate Rodman Wanamaker, whose bid to win a £10,000 ($50,000)* London Daily Mail *prize for the first transatlantic flight was cut short by World War I. During the war, the British patroled the North Sea and the English Channel in Curtiss H-4 flying boats derived from the* America. *Below right: The U.S. Navy Curtiss NC-4 flying boat was the first aircraft of any type to fly the Atlantic. Its six-man crew departed Trepassey Bay, Newfoundland on May 16, 1919, and landed in the Tagus River at Lisbon, Portugal on May 27, 1919, after a 10-day stop in the Azores.*









Above left: Pan American Airways sponsored development of the Sikorsky S-42, one of several successful flying boat types it used to build an extensive network of airline routes throughout Latin America during the mid- and late 1930s. Pan American also used S-42s to survey island-hopping commercial routes across the Central and South Pacific. Above right: The Pan American Airways China Clipper *was the first of only three Martin M-130 flying boats built. Twenty-five thousand people turned out on November 22, 1935 to see it take off from Alameda, California on its first westward flight, bound for Manila by way of Hawaii, Wake, and Guam. The* China Clipper *carried the first transpacific airmail and eventually flew more than three million miles.*

Flying Boats: Airline Builders

The very first scheduled airline in the United States—the St. Petersburg-Tampa Airboat Line—flew Benoist XIV flying boats across Tampa Bay for the first three months of 1914, believing the flying boat to be the safest means to convey passengers over water. (See January-February 1980 *Air & Space,* page 3.) This philosophy guided airline planners until World War II, when four-engine landplanes began routine ocean crossings.

The safety imparted by the flying boat's overwater capability was at the expense of its flying efficiency, for their bulkiness and inherent design were not conducive to streamlining. Nonetheless, the airlines used them to pioneer overwater routes all over the world in the late 1920s and 1930s. Not only did the flying boats offer safer passage over water than landplanes, they did not need expensive, fixed facilities as landplanes needed airports. The flying boat pilot was able to establish his own runway for each takeoff and landing. Some say that the luxury found on the later flying boats has not been duplicated by any other type of airplane.

The Sikorsky S-38 amphibian proved to be ideal for the early Pan American Caribbean routes, carrying eight passengers at 169 kilometers (105 miles) per hour.

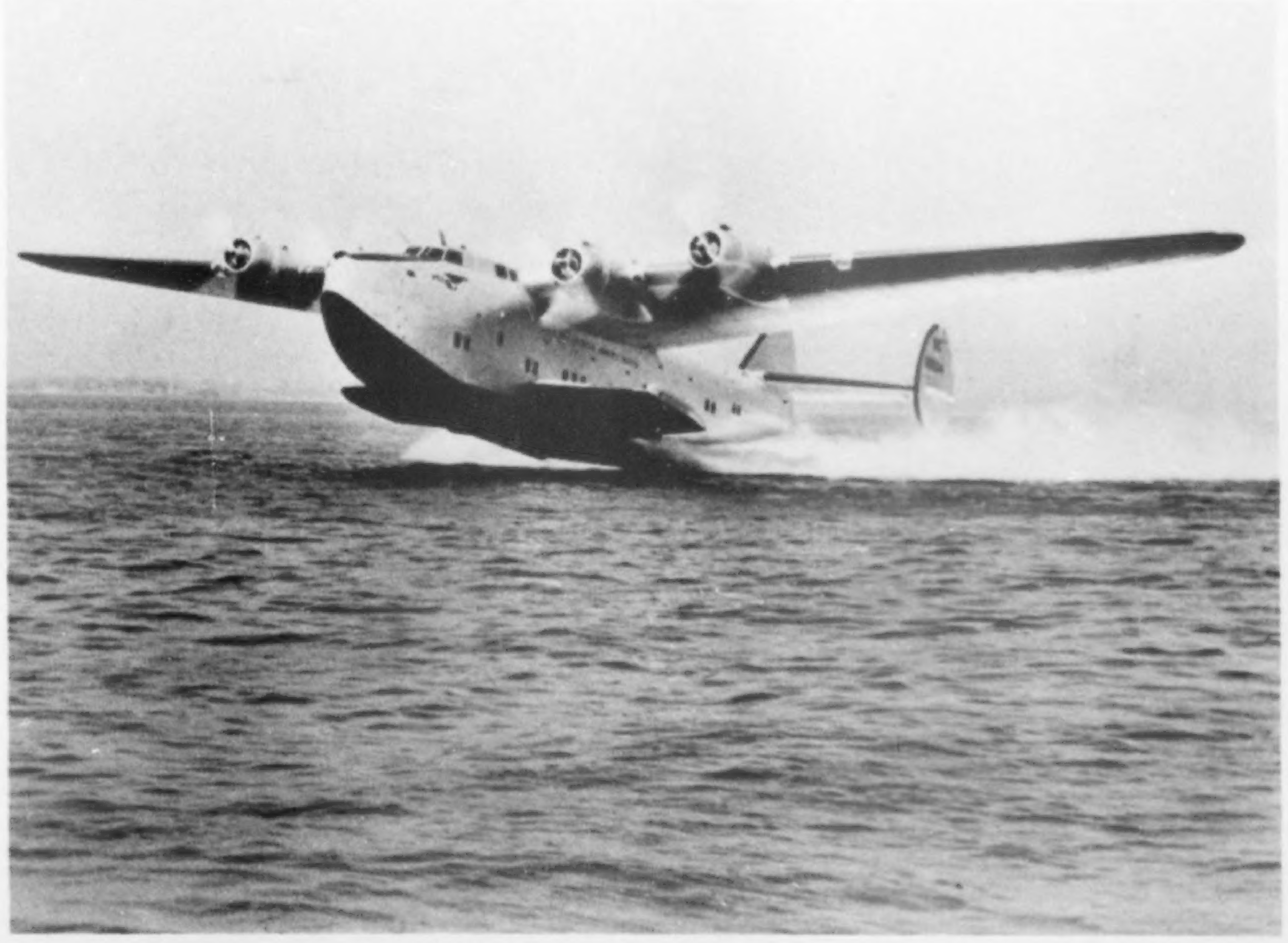
The S-38 was especially attractive for interior water routes like the Northwest Line over the Great Lakes. The amphibian capability permitted use of ordinary airfields, while the flying boat hull provided safety on the overwater portions of the route.

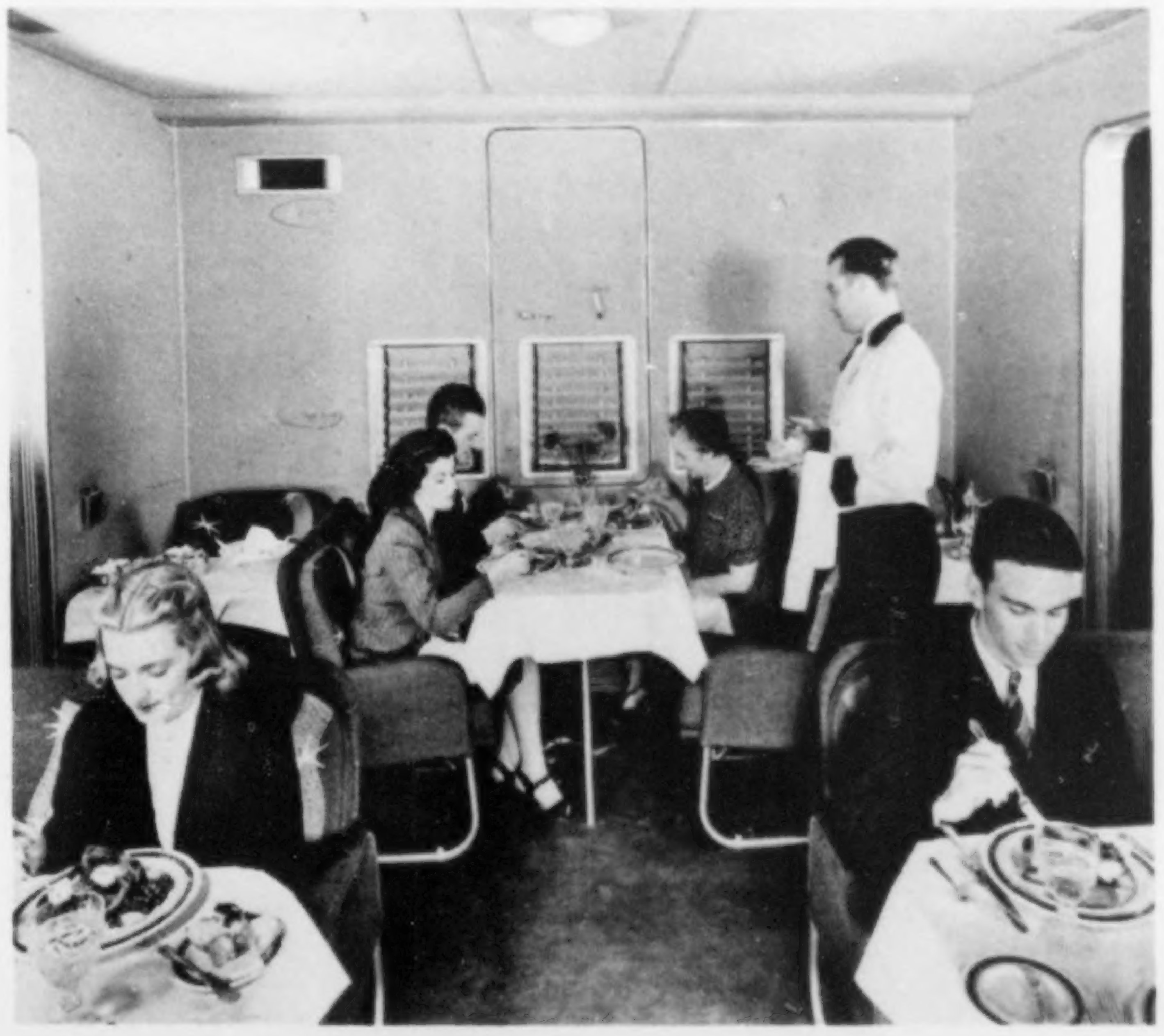
For a short time the New York, Rio, & Buenos Aires Line (NYRBA) challenged Pan American Airways' expansion into the Caribbean and South America. NYRBA's Consolidated Commodore went into service between Miami, Florida, and Santiago, Chile on February 18, 1930. It was the most comfortable flying boat yet in service, and carried 20 passengers at 164 kilometers (102 miles) per hour.

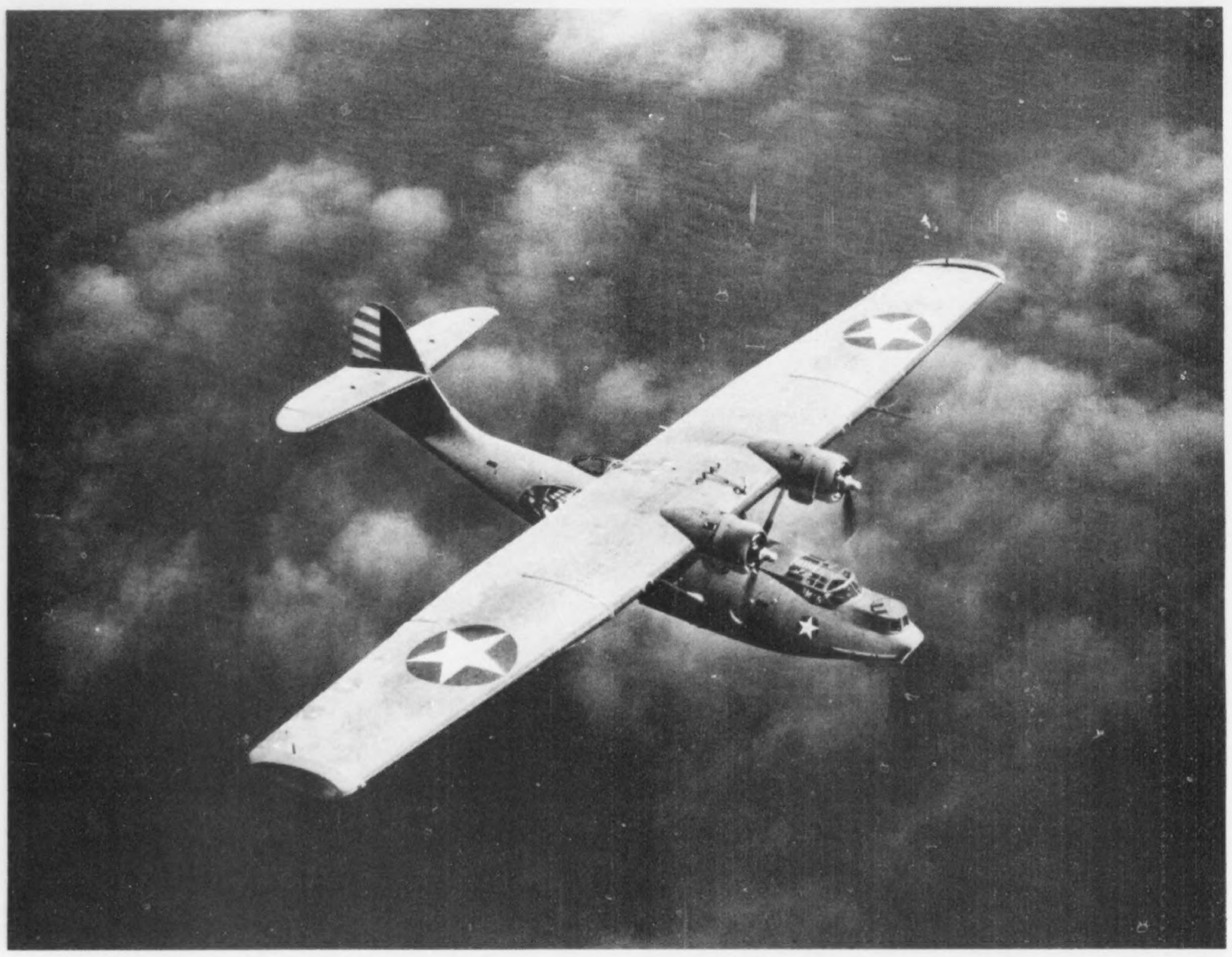
The Competitive "Clippers"

The Sikorsky S-40, successor to the S-38, was the first of what was to be a famous line of "Clippers," a trademark Pan American Airways preserves to this day. The S-40 carried 40 passengers and

Below left: The Boeing 314 was perhaps the grandest luxury flying boat to see airline use. On June 28, 1939, Pan American's Boeing 314 Dixie Clipper *inaugurated the first regular transatlantic passenger service. Below right: The 314's spacious salon offered gracious dining for 14.*







More than 3300 Consolidated PBY Catalinas —the largest number of a single flying boat type ever built—served in the U.S. Navy and allied fleets during World War II. PBYs flew long patrols and bombing missions, and performed many daring rescues of downed airmen and shipwrecked sailors.

a crew of six at a relatively slow 160 kilometers (100 miles) per hour, but it proved the value of larger flying boats.

Pan American Airways sponsored development of the Sikorsky S-42, which in 1934 offered a 40 percent increase in speed over the Consolidated Commodore while providing luxurious accommodations for 32 passengers. Its range at that time of 1200 kilometers (750 miles) precluded transoceanic service, but the S-42 gave first-class service on Pan American southern routes, and trained pilots and mechanics for later route expansion across the Atlantic and the Pacific.

Pan American also sponsored development of the famous *China Clipper*, the Martin M-130. Only three of these aircraft were built, but they established transoceanic flying as a successful venture. The M-130 could carry as many as 32 passengers, but this number was reduced on longer flights so that the M-130 could carry enough fuel to fly 4023 kilometers (2500 miles).

The *China Clipper* was a well-built, efficient airplane. Like all flying boats, it had problems associated with boarding and servicing that landplanes did not have. Barges, docks, and small boats were used to get passengers and crew aboard.

The Short Brothers Empire Class flying boats brought international airline supremacy to Great Britain in the years just before World War II. The Short Flying Boats provided seven flights per week to Egypt, four to India, three to East Africa, and two to South Africa, Malaysia, and Australia. The airplanes cruised at 247 kilometers (160 miles) per hour with either 24 day or 16 night passengers.

America regained the lead in flying boat design with the Boeing 314, the last and greatest of the waterborne "Clippers" of Pan American's fleet. The 314 was the culmination of all the lessons learned in operating the earlier Martin and Sikorsky boats. It had speed, comfort, economy, and range, and it served ably both in peace and in war. It started the first transatlantic passenger service on June 28, 1939.

World War II

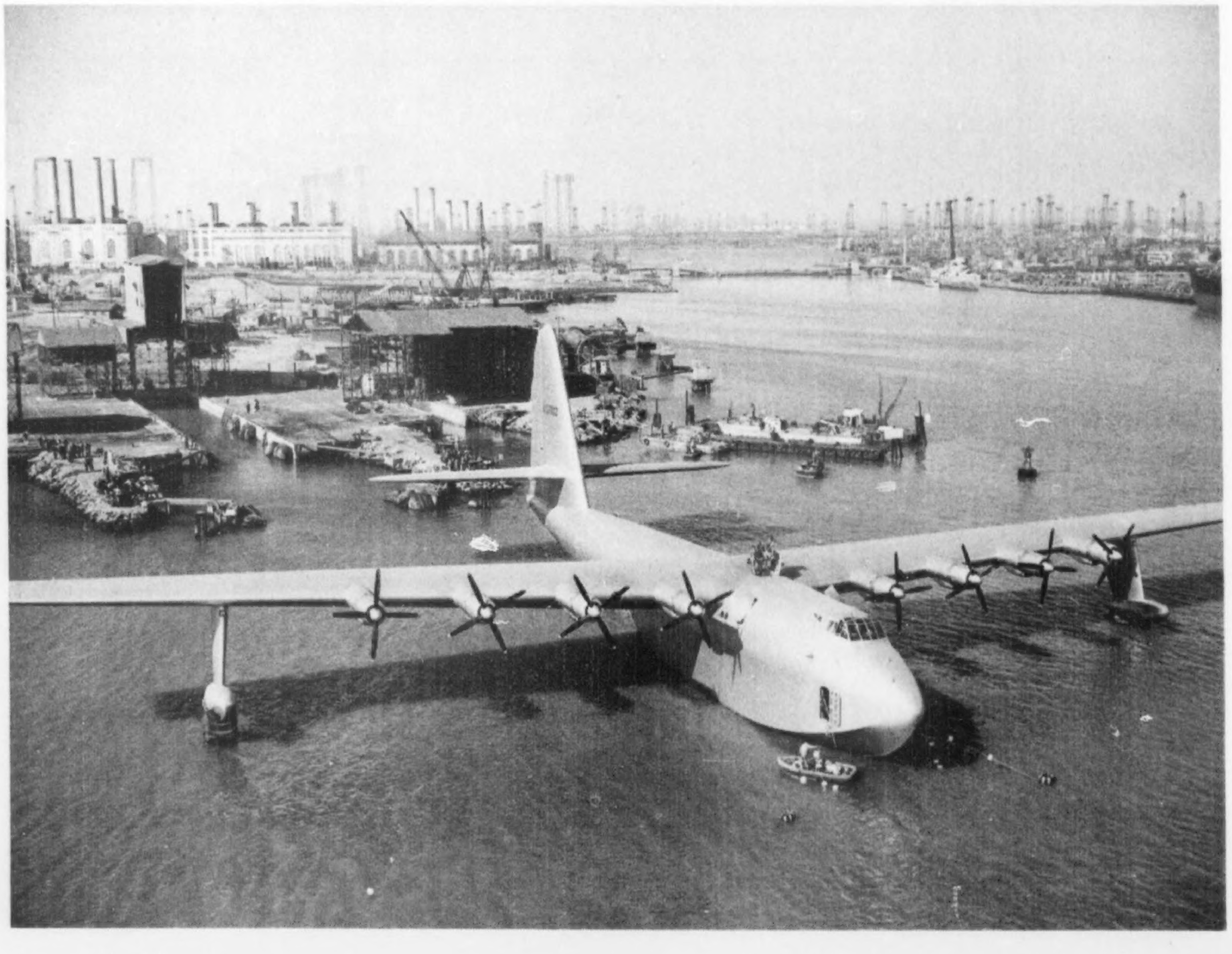
With the outbreak of World War II, long-range flying boats, such as the Royal Navy Short Sunderlands, Japanese Emilys, and U.S. Navy Consolidated Coronadoes and Catalinas, were used for reconnaissance, submarine patrol, night bombing, and air-sea rescue. More flying boats were built and flown during World War II than ever before.

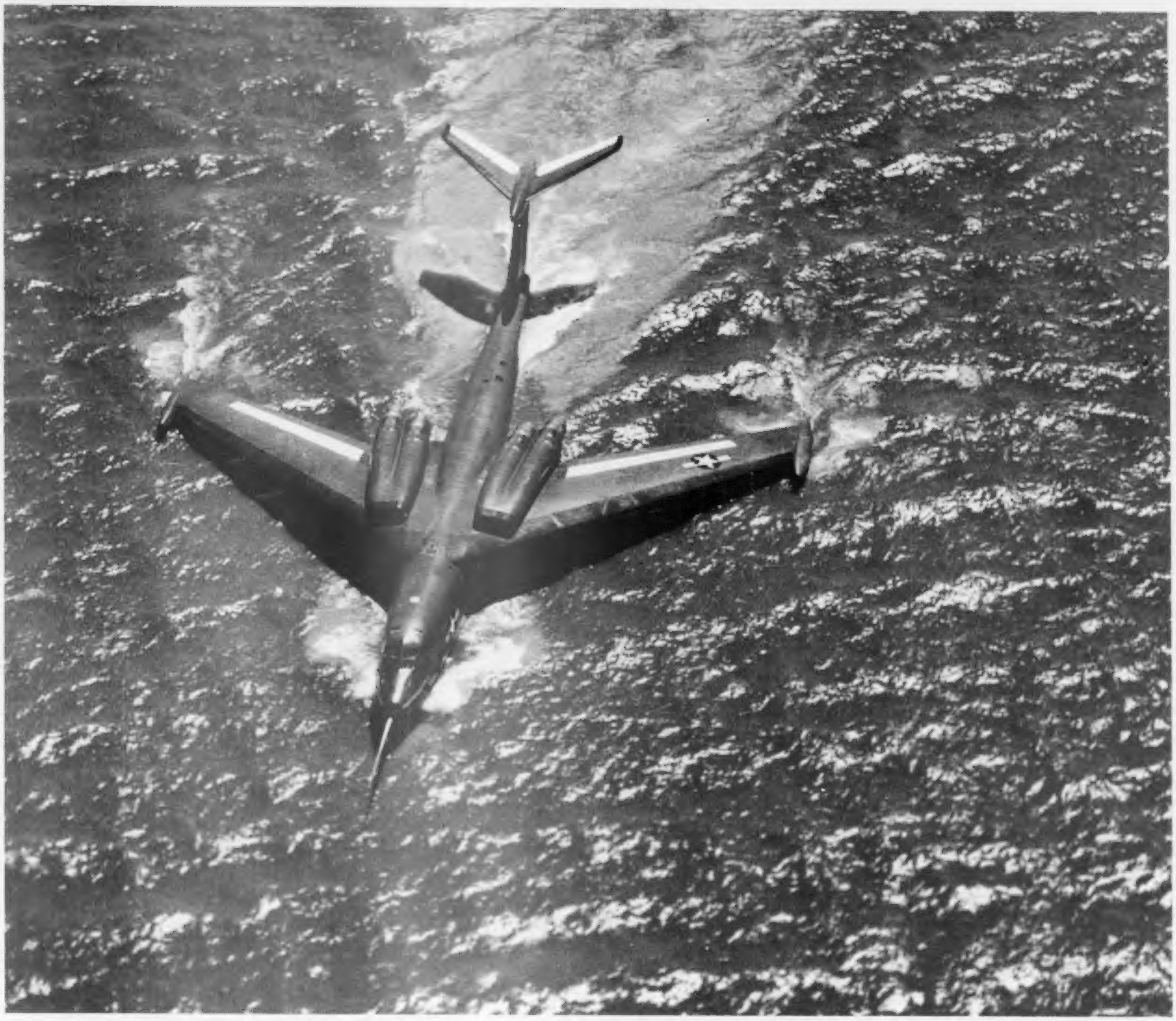
Postwar Decline—and a Comeback?

Ironically, however, other effects of the war virtually assured the rapid decline of the flying boat when peace came. During the war, many large military airfields had been built in previously inaccessible areas. After the war, these long runways beckoned to a new generation of long-range landplanes capable of routine transoceanic flight.

The last of the great American flying boats, the Hughes HK-1 Hercules, was assembled in a special facility at Long Beach, California during the mid-1940s. It has a wingspan of 97.4 meters (320 feet), largest ever of any aircraft, and a gross weight of 181,440 kilograms (400,000 pounds). Eight 3000-hp en-

Right: The eight-engine Hughes HK-1 Hercules, conceived during World War II as a transatlantic troop transport, was built from laminated birch to conserve war-critical metals. Carefully preserved since its only flight in 1947, the huge flying boat has been hangared in Long Beach, California for 32 years.





Above: The Martin P6M Seamaster, designed and tested for the U.S. Navy during the 1950s, was one of a few postwar jet flying boats. Intended to be an all-weather, high-performance mine-laying aircraft, the Seamaster incorporated advanced technology and could fly more than 966 kilometers (600 miles) per hour. Because more conventional aircraft were preferred, it did not see operational service.

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gines were intended to propel the huge flying boat and as many as 350 litter patients and medical crew at a top speed of 351 kilometers (218 miles) per hour. The HK-1 made a short flight on November 2, 1947, piloted by Howard Hughes.

Great Britain also made one last effort at a giant flying boat, the Saunders Roe Princess, powered by 10 propjet engines. Despite its high speed of 610 kilometers (380 miles) per hour, mechanical difficulties and a lack of demand kept the Princess from becoming operational.

After the war, military flying boats continued to fly submarine patrols and air-sea rescue missions, but gradually were supplanted by helicopters and landplanes based ashore or on aircraft carriers. Manufacturers in both Great Britain and the United States developed prototype jet flying boats for military purposes, but the concept did not find favor, though one or two designs flew surprisingly well.

A few flying boats survived World War II to return to civilian operations. Variants of the renowned Short Sunderland, Boeing 314, and Consolidated Catalina saw brief airline service. Some flying boats were converted for forest patrol and firefighting, roles in which they still work well. A relative handful of smaller flying boats continue to ply shorter overwater routes off the beaten track. But the large flying boat appears to have proven itself an aerial dinosaur.

Or has it?

The Shinn Meiwa Company of Kobe, Japan currently is building a flying boat for air-sea rescue. Because Japan's intensive land use prohibits extensive airport construction, Shinn Meiwa also is considering production of a series of flying boats. They range in size from a 40-passenger amphibian for inter-island flights to a turbine-powered, 1200-passenger flying boat. Perhaps the flying boat concept is not dead after all, only dormant.

Related Flight series filmstrips: *Sea-Air Operations* and *Air Transportation* (see Outreach, page 19).

FACT—OR FICTION?

Frau im Mond *vs. Apollo*

by Frank H. Winter, Research Historian
Department of Space Science and Exploration, NASM

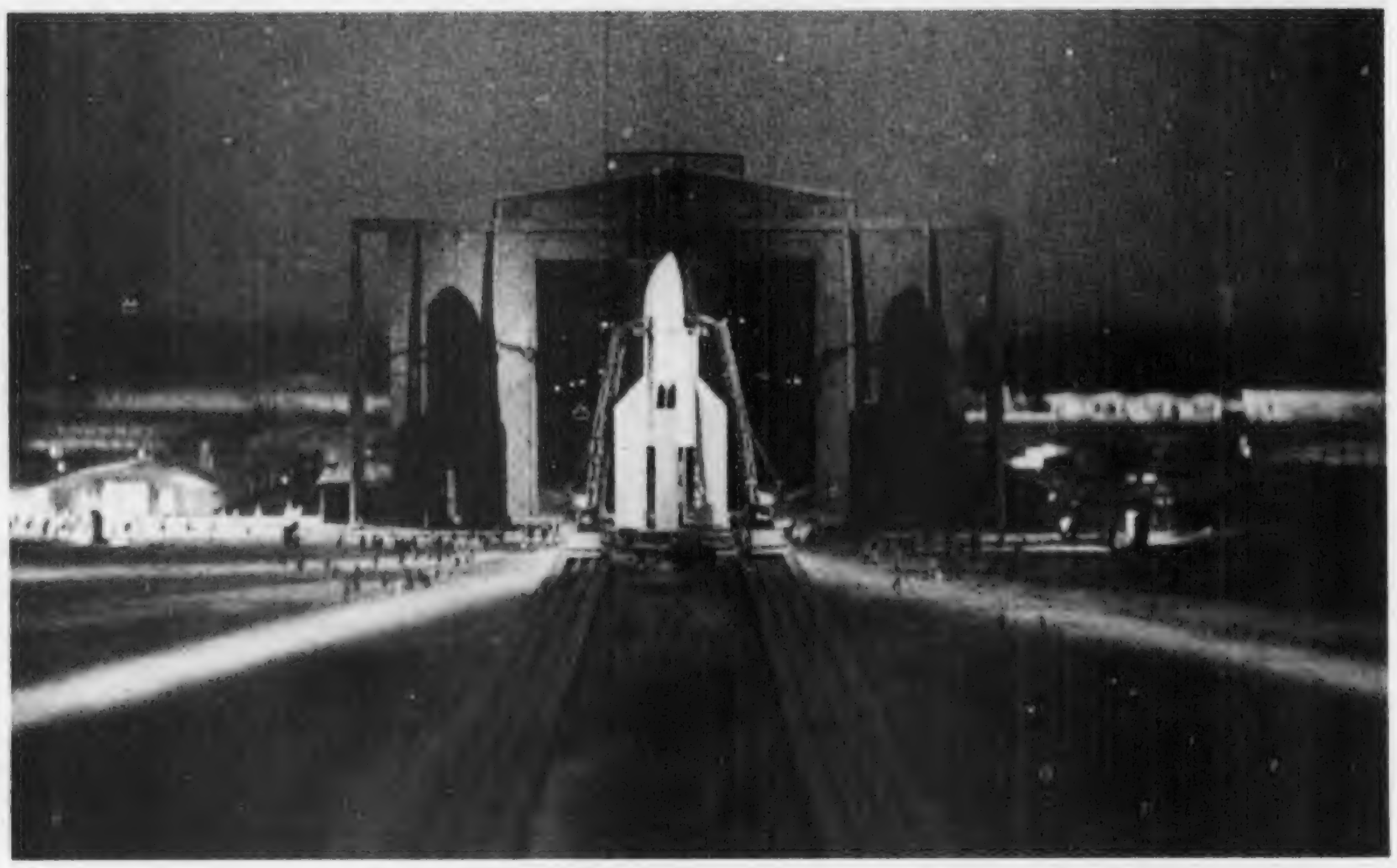
The real Space Age may be said to have begun in the 1920s and '30s with publication of the first theoretical works on spaceflight and the first experiments with liquid-fuel rockets. Newspapers, radio, and popular scientific magazines produced a wave of interest in space travel during this period.

Space travel was also glamorized by *Frau im Mond (Woman on the Moon),* a silent film produced in Germany in 1929 and shown in both Europe and the United States. *Frau im Mond* was the first space science fiction film to feature realistic sets. Producer-director Fritz Lang hired Hermann Oberth to be the film's technical advisor. Oberth's 1923 book *Die Rakete zu den Planetenraumen (The Rocket into Planetary Space)* first clearly outlined the technology and possibility of space travel.

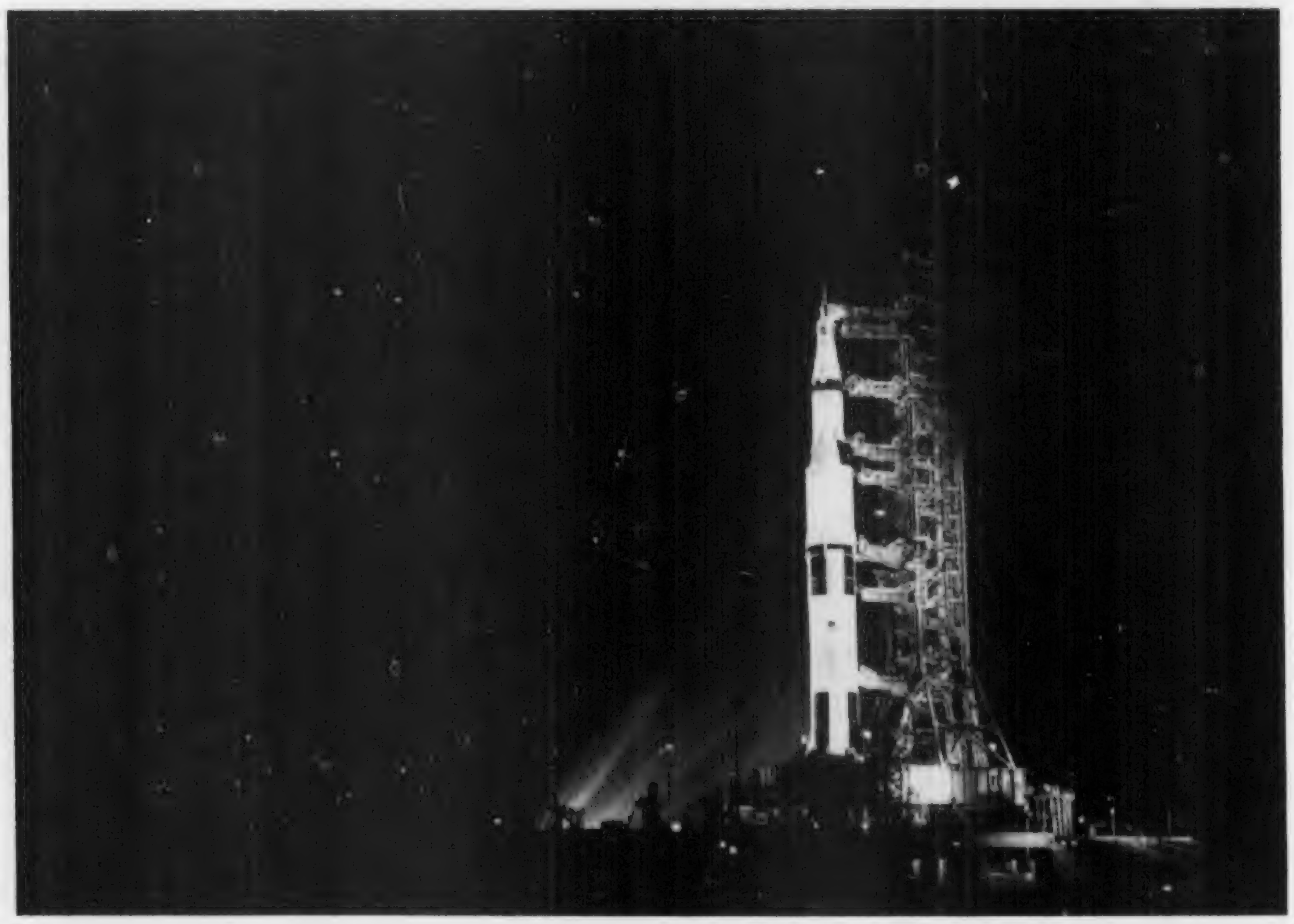
In some respects, *Frau im Mond* was prophetic; in others, it took artistic license with the scientific knowledge of the time. The following pages contrast scenes from *Frau im Mond* with similar situations from the Apollo and Skylab missions.

Visitors to the National Air and Space Museum can get a close look at the actual Apollo 11 Command Module and a backup Lunar Excursion Module. An entire NASM gallery (Apollo to the Moon) is devoted to the Apollo program, and in the Space Hall, visitors may walk through the backup Skylab. Some of the early spaceflights of fancy are represented in NASM's Rocketry and Space Flight gallery.

Related Flight series filmstrips: *Rocketry and Space Flight; Space Flight and Human Survival; Apollo to the Moon* (see Outreach, page 19).

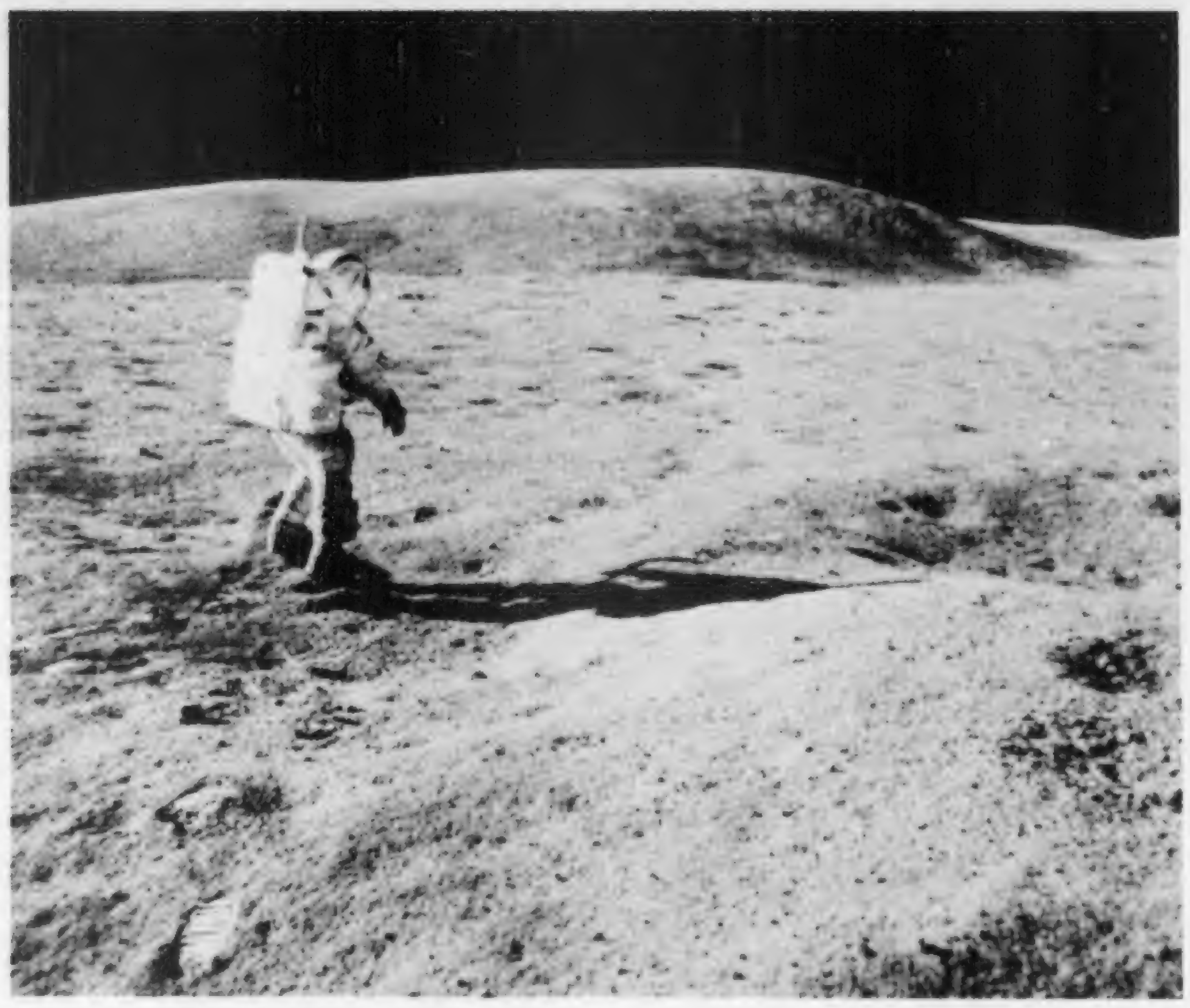


Technical advisor Hermann Oberth designed the Moon rocket for Frau im Mond *(above) that foreshadowed the night launch preparation of Apollo 16 (below) 43 years later. Oberth also incorporated the pre-launch countdown concept into* Frau im Mond. *However, Oberth's stubby, large-finned lunar rocket had only two stages; the real Moon rockets mated a three-stage Saturn V launch vehicle with a detachable Command Module, Service Module, and Lunar Excursion Module.*

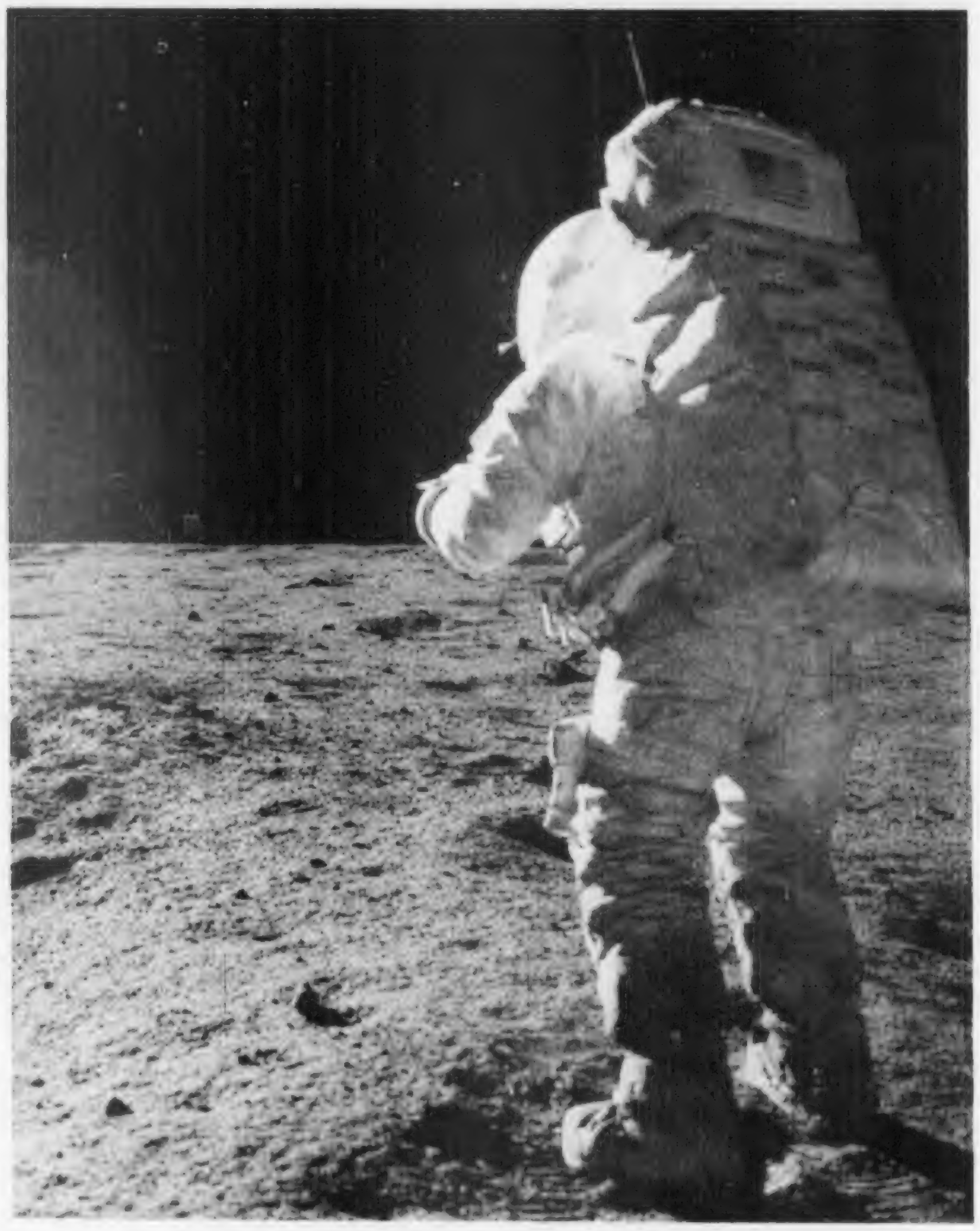


Above left: Fortunately, most spaceflight missions have not been nearly so exhausting as Frau im Mond's *fictional moon voyage. Technical advisor Hermann Oberth knew that space travelers would be subjected to the strain of acceleration after liftoff, so he furnished the studio rocket with cots and straps that his astronauts also could use when moving around during periods of weightlessness. Above right: Skylab II astronauts Charles "Pete" Conrad and Paul J. Weitz were more secure—and comfortable—than their screen counterparts. They moved throughout the orbiting Skylab by means of special restraints or by tether devices that affixed to many locations inside the spacecraft.*

Above: There is no air on the Moon, but Fritz Lang, producer-director of Frau im Mond, *insisted that his Moon travelers find air so that they would not have to wear diving suit type spacesuits. Lang made one concession to scientific accuracy in the lunar surface scenes—his astronauts wore special weighted shoes to counter the light gravity of the Moon, only one fifth as great as Earth's. Right: Apollo 16 astronaut Charles M. Duke, Jr. and the other later Apollo moonwalkers explored lunar terrain that was mountainous, but not nearly as precipitous as the set backdrop in* Frau im Mond. *Real lunar soil is much more grainy and varied than the tons of beach sand brought to the Ufa (Universal Film Company) studio in Berlin for the film.*



Frau im Mond's solitary moonwalker (above left) found the same loneliness and stark beauty that Apollo 16 astronaut Charles M. Duke discovered (above right). But the Apollo astronauts were in constant communication with each other and the Earth during their lunar sojourns, and spent almost all of that precious time collecting geological samples and performing experiments. In contrast, Frau im Mond's *Moon travelers were looking only for gold (scientific advisor Oberth had no say in the matter). The Apollo missions confirmed scientists' beliefs that the Moon contains very little gold, and that the geological processes that create mineral veins and ores on Earth do not occur on the Moon.*



Left: For the sake of the movie audience, director Lang embellished his fictional lunar surface with crude plant life nurtured by a hot, bubbling spring. Above: Apollo astronaut Edgar D. Mitchell surveyed the desolate lunar highlands in 1971. No signs of past or present life have been found on the Moon. Oberth and other spaceflight theorists specialized in rocketry and navigation, but virtually ignored lunar and planetary science.

Top left: The F4U-1D Corsair is the type presently undergoing restoration at NASM's Paul E. Garber Preservation, Restoration, and Storage Facility at Silver Hill, Maryland. Many U.S. Navy and Marine Corps pilots became aces in the F4U Corsair. Top right: Major Gregory W. "Pappy" Boyington, USMC, was Commanding Officer of the "Black Sheep" squadron, and was awarded the Medal of Honor for his performance in aerial combat during World War II.

"BLACK SHEEP"

by E.T. Wooldridge, Jr.
Associate Curator
Department of Aeronautics, NASM

Few World War II heroes have recaptured the public's interest and imagination as has "Pappy" Boyington, hero of "Baa Baa Black Sheep," a television series very loosely based on Boyington's aerial exploits in the South Pacific. The top-ranked U.S. Marine Corps fighter ace of World War II, he scored 28 victories. (An ace is a combat pilot who has destroyed five or more enemy aircraft.)

Gregory W. Boyington grew up in Tacoma, Washington, and graduated from the University of Washington in 1934. After receiving his commission in the U.S. Marine Corps in 1937, he served for four years before resigning his commission to fly Curtiss P-40 Warhawks for the American Volunteer Group (AVG) in China. Under the leadership of the famous General Claire Chennault, Boyington destroyed six Japanese bombers during his months with the "Flying Tigers."

After dissolution of the AVG in July 1942, Boyington rejoined the Marine Corps. He eventually found himself back in combat, flying the hottest fighter plane in the South Pacific, the renowned Vought-Sikorsky F4U Corsair. As Commanding Officer of Marine Fighter Squadron 214, known as the "Black Sheep," Major Boyington found lasting fame. A dynamic, colorful leader and a superb, instinctive fighter, he molded an unusual assortment of rejects, transfers, and replacements into a legendary fighting unit. The other "Black Sheep" gave Boyington the nickname "Pappy" because he was older and more experienced than the rest of them. Led by Boyington himself, who destroyed 14 Japanese aircraft in 32 days, the "Black Sheep" destroyed a record 148 enemy planes during two periods of intense aerial combat.

On January 3, 1944, during a fighter sweep over the Japanese naval stronghold at Rabaul, New Britain, "Pappy" downed his 27th and 28th enemy aircraft but, fighting against overwhelming odds, was shot down himself. Severely wounded, he was plucked from the ocean by a Japanese submarine and eventually was imprisoned in Japan. Boyington was released at the end of the war, and later was awarded the Medal of Honor by President Truman for leading his squadron into combat ". . . with devastating results to enemy shipping, shore installations, and aircraft." "Pappy" Boyington retired from the Marine Corps in 1946 as a Lt. Colonel.

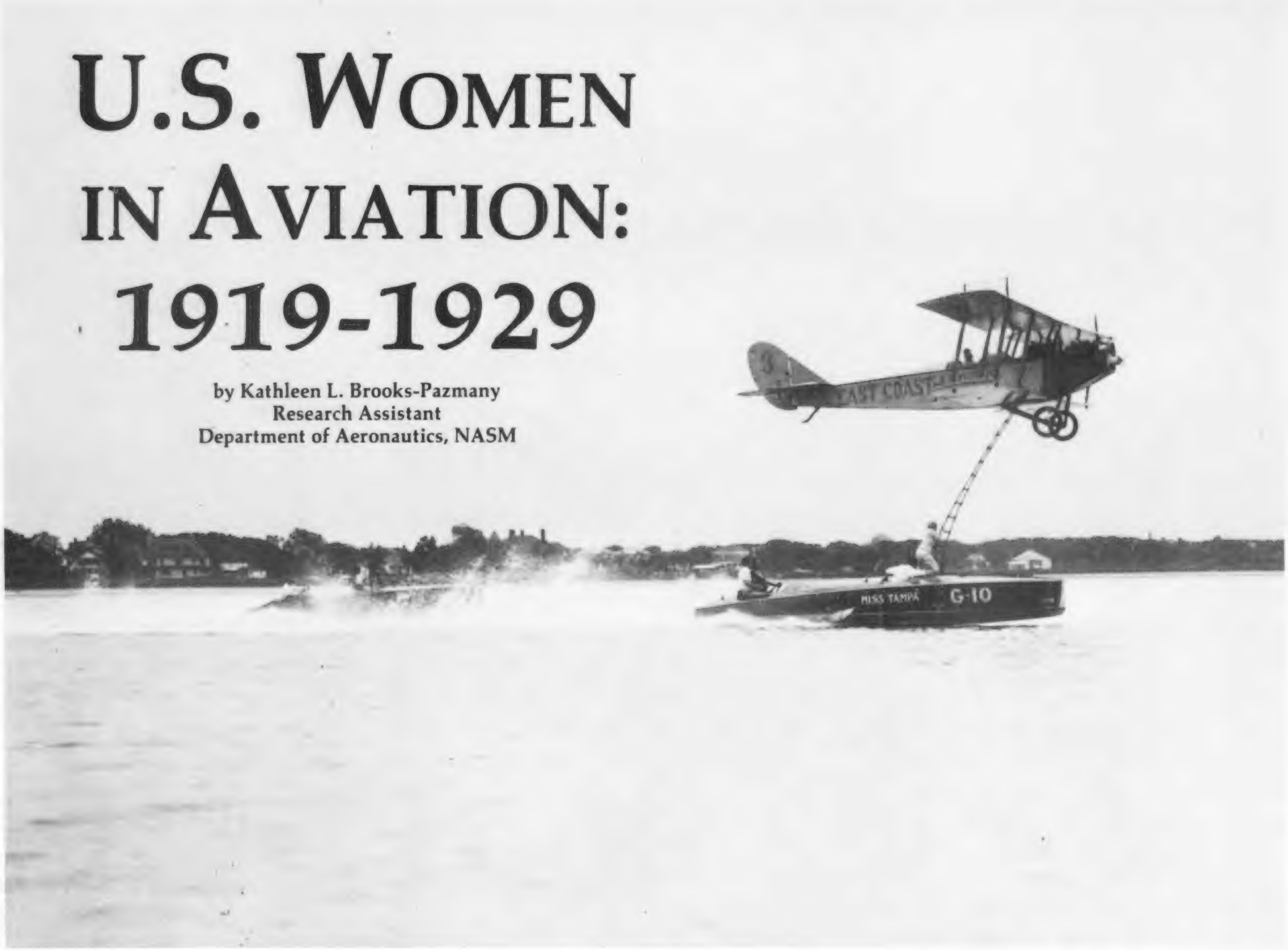
The Vought-Sikorsky F4U Corsair flown by the "Black Sheep" and many other U.S. Navy and Marine Corps aces earned a reputation as one of the best U.S. fighters in World War II. With its distinctive inverted gull wing and the most powerful engine available at the time (the Pratt & Whitney R-2800 Double Wasp), the F4U acquired a number of nicknames—Bent Wing, U-Bird, Whistling Death. More importantly, however, it was credited with an 11:1 ratio of kills to losses in action against Japanese aircraft. By the end of the war, Corsairs had shot down 2140 enemy planes, with a loss of only 189 F4Us, and had fought from the Solomon Islands to the Indian Ocean and from the South China Sea to Norway. Blessed with superior speed, rate of climb, maneuverability, and excellent overall performance, Corsairs functioned with equal success as interceptors, bomber escorts, fighter-bombers, night fighters, and dive bombers.

The National Air and Space Museum is currently restoring its Vought-Sikorsky F4U-1D Corsair at the Paul E. Garber Preservation, Restoration, and Storage Facility in Silver Hill, Maryland. The Corsair is scheduled to be placed on display at NASM about October 1980.

Related Flight series filmstrips: *Sea-Air Operations* and *World War II Aviation* (see Outreach, page 19).

U.S. WOMEN IN AVIATION: 1919-1929

by Kathleen L. Brooks-Pazmany
Research Assistant
Department of Aeronautics, NASM



Billed as "the world's greatest aerialist and transfer artist," Mabel Cody thrilled audiences during the 1920s with her daring stunts.

When most civilian flying in the United States was curtailed by the outbreak of World War I, women pilots soon found ways to keep flying. They led Red Cross and Liberty Loan fundraising campaigns, participated in military recruiting drives, and served as flight instructors. The news media stimulated public interest in aviation with stories of America's flying boys at the front, and recruiting and loan drives brought airplanes to people who had never before seen them.

It was through one of these loan drives that Laura Bromwell obtained her first airplane ride. The flight so enthralled her that she decided to learn to fly as soon as the war ended. She did; on October 22, 1919, Ms. Bromwell became the first woman to receive a postwar pilot's license from the Aero Club of America. (The U.S. government did not license pilots until 1926.)

Exhibition Flying

The end of the war had a profound impact on aviation. Hundreds of military aircraft were declared surplus, making planes affordable. But production slumped, and the job market was flooded with ex-military pilots. In 1919 there was little chance that a woman would find a position in aviation.

Laura Bromwell became one of the fortunate few when she joined the New York City Aerial Police Reserves. One of her duties was to fly in aerial exhibitions at special events. In this she excelled; on August 15, 1920, she astounded a crowd at Curtiss Aerodrome, Mineola, New York when she looped her Curtiss J-1 at least 87 times. (Later, Ms. Bromwell flew 199 consecutive loops.) Less than one year later, she crashed and was killed while flying a Canadian Curtiss JN-4 with which she was not familiar.

With so few flying jobs available, many pilots went into business for themselves as barnstormers. Traveling around the country, they thrilled spectators with death-defying aerial feats, selling airplane rides and tickets to their performances. In 1925, Mabel Cody led one of the most successful flying circuses. She performed incredible stunts, transferring from car to plane and from speedboat to plane, and making freefall parachute jumps.

That was a difficult way to make a living. It was even more difficult for a black woman. When Bessie Coleman could find no one in the United States who would teach her to fly, she went to France. In 1921, she became the first licensed black woman pilot in the United States. Ms. Coleman began barnstorming in 1922, and because of her race always drew large crowds. Her career came to a tragic end on April 30, 1926. While she was test-flying her plane, the controls jammed, and she fell to her death.

Transoceanic Flights

Charles Lindbergh's New York-to-Paris flight in May 1927 triggered a series of ocean-crossing attempts involving women. On August 12, 1927 Mildred Doran took off from Oakland, California as a passenger in the *Miss Doran*, a Buhl Air Sedan biplane bound for

Laura Bromwell, a New York City Aerial Police Reserves exhibition pilot, turned heads in 1920 when she flew more than 87 consecutive loops, besting the women's record of 25 loops.

Bessie Coleman was the first licensed black woman pilot in the United States. She dreamed of opening a flying school for blacks, but died in a crash before achieving that dream.

Mildred Doran, the "Flying Schoolmarm," disappeared during the 1927 Dole Race in Hawaii while trying to become the first woman to cross an ocean by airplane.

Hawaii in the Dole Race. The airplane and its crew were never found. Ms. Doran was the first woman to attempt an ocean crossing. Ruth Elder almost succeeded in crossing the Atlantic. As copilot to George Haldeman, she took off October 11, 1927 from Roosevelt Field, Long Island, New York. Bad weather and mechanical problems forced their Stinson Detroiter *American Girl* into the ocean, where they were rescued by a Dutch freighter.

Not until June 18, 1928 would a woman succeed in crossing an ocean by airplane. The day before, Amelia Earhart departed from Trepassey Bay, Newfoundland as a passenger in the Fokker Tri-motor *Friendship*. Twenty hours and 40 minutes later, she landed off the shore of Burry Port, Wales; though she had not piloted the airplane, Ms. Earhart was hailed as a heroine.

Record Flights

To obtain recognition of their skills and capabilities, some women began competing for altitude, endurance, and speed records. However, their marks still fell short of those set by men. Then, at the June 1929 Fédération Aéronautique Internationale Conference, a separate category was established for women's records. Women's accomplishments could now be measured against their own progress.

The year 1929 witnessed a spectacular aviation event—the National Women's Air Derby. This grueling eight-day cross-country air race proved beyond doubt what capable and skillful pilots women could be.

On August 18, 1929, 19 women took off from Santa Monica, California, headed for Cleveland, Ohio. Their route took them over deserts, mountains, and plains. They flew alone, navigating only by roadmaps and compasses. One pilot, Marvel Crosson, lost her life in the desert; several others had close calls. Yet despite sandstorms, route changes, little sleep, and innumerable mishaps, 15 pilots completed the race. Louise Thaden was the first to cross the finish line on August 26; she was followed throughout the day by 13 others. One determined pilot arrived the following day.

The formation of the Ninety-Nines brought the decade to a close. Licensed women pilots were invited to meet on November 2, 1929, at Curtiss Field in Valley Stream, New York, to discuss the establishment of a women pilot's organization. Its purpose would be to share information of mutual interest and to provide encouragement and assistance to current and future women pilots. Twenty-six women met at Curtiss Field; 99 answered the invitation to join, giving rise to the group's name, the Ninety-Nines. Today their membership in the United States and abroad numbers in the thousands. They keep alive the spirit of resourcefulness and determination that sustained the original 99—and all the other women who flew more than 50 years ago.

After her triumphant finish in the 1929 National Women's Air Derby, Louise Thaden (left) said of her fellow competitors, "All the girls flew a splendid race, much better than I. Each one deserves first place, because each one is a winner."

WEATHER SATELLITES

Twenty Years Since TIROS I

by J. Gordon Vaeth
Director, Office of Systems Engineering
National Environmental Satellite Service

Far left: TIROS I (Television Infra-Red Observation Satellite), similar to TIROS III shown here, was launched April 1, 1960 and ushered in an age of global weather-watching from space. Near left: The disk of the Earth as seen by a GOES (Geostationary Operational Environmental Satellite) spacecraft. North and South America curve along the right half of the disk.

At 6:40 a.m. on April 1, 1960, the world's first weather satellite was launched from Cape Canaveral atop a Thor-Able rocket. Called TIROS, an acronym for Television InfraRed Observation Satellite, it weighed 122 kilograms (269 pounds) and was shaped like a hatbox.

Overnight TIROS gave meteorologists a dramatic new tool. Now they could "see" storm systems from a vantage point 830 kilometers (516 miles) high. TIROS' vidicon cameras and infrared sensors quickly proved their value for forming images of the Earth's cloud cover and measuring the temperature of cloud tops and the Earth's surface. Meteorologists could also observe the weather in remote oceans and other areas for which reliable weather reports were otherwise scarce and difficult to obtain. A new scientific day had been born, one that held out to meteorologists the promise of eventually monitoring the Earth's weather over its entire surface.

That promise has long since been fulfilled.

Today U.S. weather satellites—more correctly called environmental satellites—provide not only global weather coverage but a variety of associated services as well. The federal agency that operates these spacecraft and provides these services is the National Environmental Satellite Service (NESS), a part of the National Oceanic and Atmospheric Administration (NOAA). NASA's Goddard Space Flight Center at Greenbelt, Maryland develops, builds, and launches these spacecraft for NOAA in response to NOAA's observational requirements. After the satellites are launched, commanding and controlling them—as well as "reading them out" and distributing their data to environmental users—becomes NOAA's responsibility.

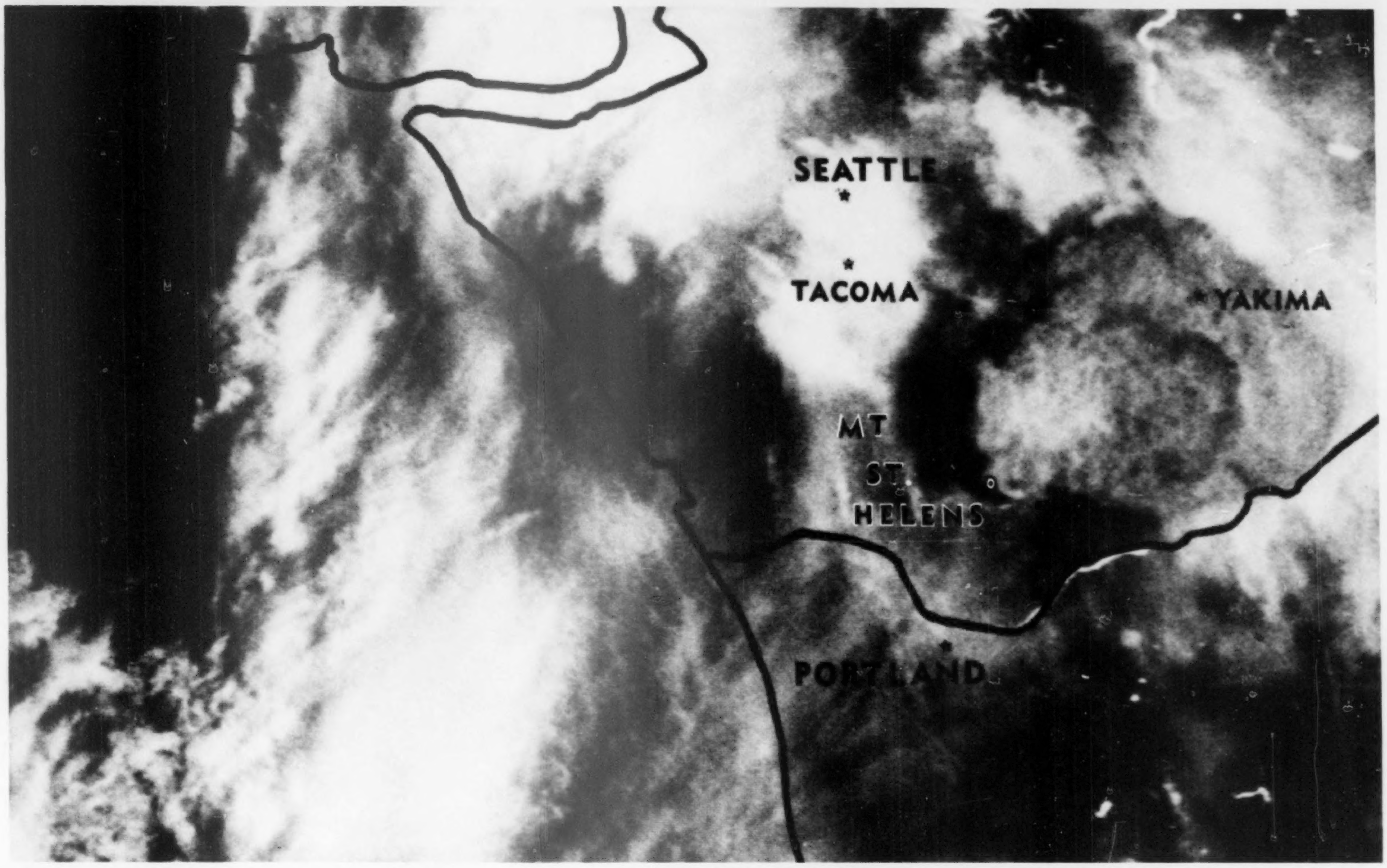
Between 1960 and 1965, 10 TIROS spacecraft were orbited—all successfully. Although they were primarily intended as developmental payloads, their observations were so immediately applicable to the needs of the meteorological community that they quickly became the basis for a semi-operational system.

These first TIROS satellites were succeeded by nine TOS (TIROS Operational Satellite) spacecraft, launched between 1966 and 1969. (After launch, TOS vehicles were referred to as ESSA satellites. ESSA was an acronym both for Environmental Survey Satellite and for the Environmental Science Service Administration, the federal agency that operated the spacecraft. This organization later became NOAA.) TOS vehicles flew in pairs: one carried an Advanced Vidicon Camera System that took and stored television-like pictures for later transmission to a major receiving center; the other employed an Automatic Picture Transmission (APT) system that broadcast its photos continuously to any ground station within range. The TOS craft were followed by six ITOS (Improved TOS) between 1970 and 1976.

Meanwhile, as these operational TIROS satellites routinely observed the weather over the entire globe, NASA was testing improved instruments and sensors on its flying test bed, the Nimbus satellite. Seven Nimbus spacecraft were put into orbit between 1964 and 1978.

Latest in the TIROS series is the current TIROS-N, a multi-capability heavyweight (1361 kilograms, or 3000 pounds) compared to the early TIROS. TIROS-N is a polar orbiter—i.e., its orbit sweeps across Earth's north and south polar regions—and it "sees" every point on Earth at least twice a day (once in daylight, once at night). Two TIROS-N satellites are maintained in orbit at altitudes of 850 kilometers (528 miles) and 815 kilometers (506 miles).

The first TIROS-N rode into orbit on October 13, 1978 aboard an Atlas-F launch vehicle. Subsequent members of



Above: The ash cloud of Mt. St. Helens appeared as a grayish circular patch to environmental satellite NOAA-6. The image was taken at 9:54 a.m. Pacific Daylight Time, May 18, 1980, shortly after the long-dormant volcano's devastating eruption.

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the series are named NOAA.

Completing an orbit of the Earth approximately every 102 minutes, these TIROS-N/NOAA spacecraft carry an Advanced Very High Resolution Radiometer. This radiometer scans across the orbital track in the visible, near-infrared, and far-infrared segments of the electromagnetic radiation spectrum, gathering information for daytime and nighttime cloud mapping, surface water identification, and sea surface temperature measurements.

A TIROS Operational Vertical Sounder, which measures infrared and microwave radiation, profiles the vertical distribution of temperature within the atmosphere. In addition, a Space Environment Monitor measures solar particles encountered in flight. A Data Collection System, provided by France, receives data by radio from environmental platforms on the Earth's surface and, if the platforms are moving (such as free-drifting buoys and balloons), determines their positions.

TIROS-N/NOAA spacecraft have the Automatic Picture Transmission (APT) feature that has been used since TIROS 8 to provide direct readout of satellite cloud pictures to local users. The APT data are received by more than 800 simple ground stations throughout the world, many of them "homemade" by students or amateur radio operators.

The TIROS-N/NOAA class spacecraft is complemented by the GOES or Geostationary Operational Environmental Satellite. (A geostationary or geosynchronous satellite is one that travels around the Earth's equator at the same angular rotational speed as the Earth so that the satellite seems to remain in the same position above the Earth.)

NOAA routinely keeps one each of these GOES satellites positioned above longitudes 75° W (Colombia) and 135° W (central Pacific Ocean). About 35,000 kilometers (22,000 miles) above the equator, the Visible and Infrared Spin Scan Radiometer (VISSR) on each GOES has an expansive, uninterrupted view of the Earth. Consequently GOES is an ideal platform from which to observe the movement of rapidly-developing weather phenomena, especially severe local storms that breed tornadoes. Each GOES also carries a Space Environmental Monitor and a U.S.-provided Data Collection System for obtaining data by radio relay from river gauges, ocean buoys, tide gauges, seismometers, ships, and aircraft.

Five GOES-type satellites have been placed in orbit and used operationally since 1974. Japan and the European Space Agency each have put up a similar type of satellite to provide GOES-type coverage and services in their parts of the world.

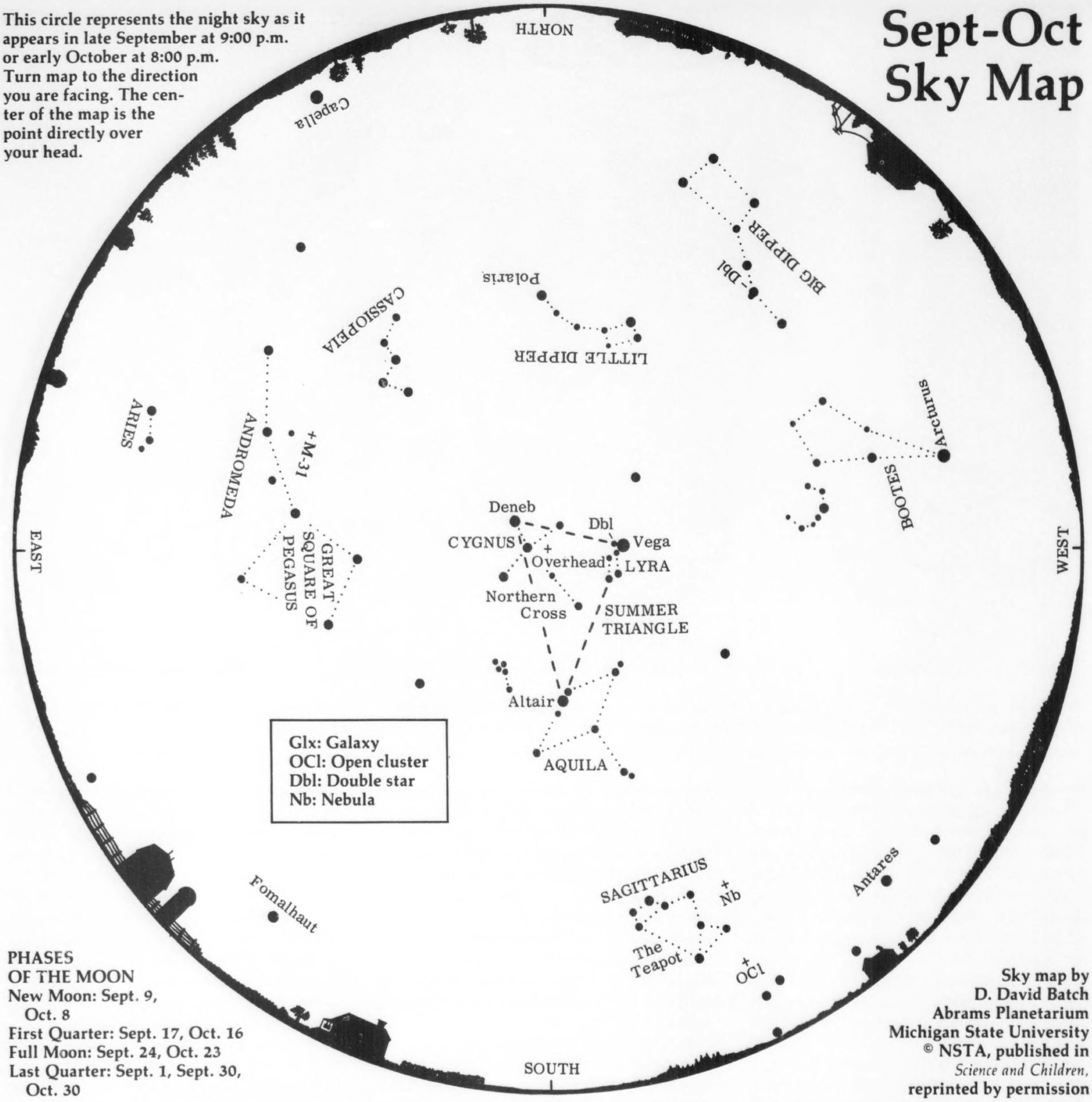
Environmental satellites have made possible great breakthroughs in monitoring the Earth's ever-changing weather. This has led to a continuing demand for more observing capability, better communications, and faster processing and dissemination of data. Improved instruments and radio techniques are in the works; so are new families of spacecraft, such as that being planned for NOSS, the National Oceanic Satellite System. Environmental satellites promise to become even more important to our increasingly environment-conscious world.

Visitors to NASM will find examples of the TIROS, TOS/ESSA, and ITOS environmental satellites on display in the Satellites gallery.

Related Flight series filmstrips: *Satellites* and *Social Impact of Flight* (see Outreach, page 19).

Sept-Oct Sky Map

This circle represents the night sky as it appears in late September at 9:00 p.m. or early October at 8:00 p.m. Turn map to the direction you are facing. The center of the map is the point directly over your head.


NORTH
Capella
BIG DIPPER
Dbl
Polaris
CASSIOPEIA
LITTLE DIPPER
ARIES
ANDROMEDA
+M-31
Arcturus
BOOTES
EAST
WEST
Deneb
Dbl
Vega
CYGNUS
+Overhead
LYRA
GREAT SQUARE OF PEGASUS
Northern Cross
SUMMER TRIANGLE
Altair
AQUILA
Glx: Galaxy
OCl: Open cluster
Dbl: Double star
Nb: Nebula
Fomalhaut
SAGITTARIUS
+Nb
The Teapot
+OCl
Antares
SOUTH

PHASES OF THE MOON
New Moon: Sept. 9, Oct. 8
First Quarter: Sept. 17, Oct. 16
Full Moon: Sept. 24, Oct. 23
Last Quarter: Sept. 1, Sept. 30, Oct. 30

Sky map by
D. David Batch
Abrams Planetarium
Michigan State University
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Science and Children,
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by T. H. Callen II
Production Specialist
Albert Einstein Spacearium, NASM

Fall is an appropriate time to talk about the origins of the expression "harvest moon" which, like the terms "honey moon" and "blue moon," describes a phenomenon long observed by skywatchers.

The harvest moon is the first full Moon following the first day of fall (the autumnal equinox), which comes on or about September 23. This year, the autumnal equinox occurs on Monday, September 22. The next full Moon is on Wednesday, September 24; the Moon seen for a few days before and after this date will be a harvest moon.

What makes the harvest moon different from any other full Moon is that it rises shortly after sunset for several days, its light helping to extend harvesters' working hours. The harvest moon effect is more pronounced at middle to higher latitudes. In the southern hemisphere, a similar harvest moon effect occurs around March 21, which is the autumnal equinox there and the vernal equinox in the northern hemisphere.

John R. Percy, editor of the annual Observer's Handbook published by the Royal Astronomical Society of Canada, suggests that the word *honeymoon* derives from the phrase "honey moon." During June—traditionally a popular month for weddings—the full Moon is low above the southern horizon. Celestial objects seen low in the sky appear redder because their light passes obliquely through the Earth's light-scattering atmosphere, which scatters other wavelengths more than red light. Thus the June full Moon appears a golden honey color.

The "blue moon" phenomenon, whose extreme rarity is the source of the expression "once in a blue moon," is believed to be caused when moonlight is scattered by fine particles of a certain size suspended in the atmosphere. These particles may be lofted by a variety of means, including desert sandstorms, volcanic eruptions, and large forest fires.

OUTREACH

by Kerry M. Joëls
Chief, Education Services Division

This issue marks the fourth school year during which *Air & Space* has been published. In little more than four years, the National Air and Space Museum has become the most visited building in the world. The Museum's Education Services Division has added a broad spectrum of education programs and services to its original responsibilities of providing school programs and public tours. We now also conduct special programs in multi-cultural education, special education, teacher education and, of course, outreach. This fall, our Regional Resource Person Program and media outreach programs will be enhanced by the debut of the Museum's new educational filmstrip series.

Covering the major aspects of the history and social significance of mankind's exploration of the air and space, the Flight filmstrip series addresses the true challenge of museum outreach. The series offers classroom teachers a valuable set of teaching tools, bringing into the classroom resources, activities, and ideas otherwise difficult to share as a common experience.

Starting with the beginnings of aviation—*Balloons and Airships, Early Flight,* and *Important Feats of Aeronautics*—the series introduces students to the development of aviation through the two World Wars, and in *Sea-Air* (Naval) *Operations.* Filmstrips on *Great Spacecraft and their Accomplishments; Rocketry and Spaceflight; Satellites; Apollo to the Moon;* and *Cosmic Awakening* provide insight into the history and development of space exploration. Special subjects, including *Flight Testing; Flight Technology; The Challenge of Restoration;* and the story of *The Creation of the National Air and Space Museum* round out a total of 21 titles.

Each of these 21 subjects has been produced in both an elementary and a secondary version. Each of the filmstrip packages contains an audio cassette, a filmstrip (two cassettes and two filmstrips in the secondary packages), a wall chart, a *User's Guide,* reproducible materials, and a library card. The filmstrip packages will be available in November 1980. For more information, call or write the National Audiovisual Center, Reference Section EH, National Archives and Records Services, General Services Administration, Washington, D.C. 20409, telephone (301) 763-1896. Allow six weeks for response to orders and written requests for information.

The introduction of this filmstrip series also accompanies a modest change in *Air & Space.* Special activities and articles appearing in *Air & Space* will be correlated with the filmstrip series, making *Air & Space* a continued curriculum update for users of the series.

Virtually every department in the National Air and Space Museum participated in the creation of this series. It is our fervent hope that it will serve the education community as well as the Museum itself. We created it for you, and we hope you enjoy it.

Presentations on Aviation and Space Available

NASM has parepared 29 educators to give presentations in their communities on the history and significance of aviation and space.

The educators participated in Regional Resource Person Training Sessions held in July 1979 and 1980 at NASM in Washington, D.C. The educators have returned to their communities where they will be available to teach other instructors ways to integrate aeronautics and astronautics into the school curriculum.

These Regional Resource Persons will make presentations to teachers, students, and to the general public:

Tom Anderson, Visitors Center, Kennedy Space Center, FL;

Linda C. Andrews, Memorial High School, Houston, TX;

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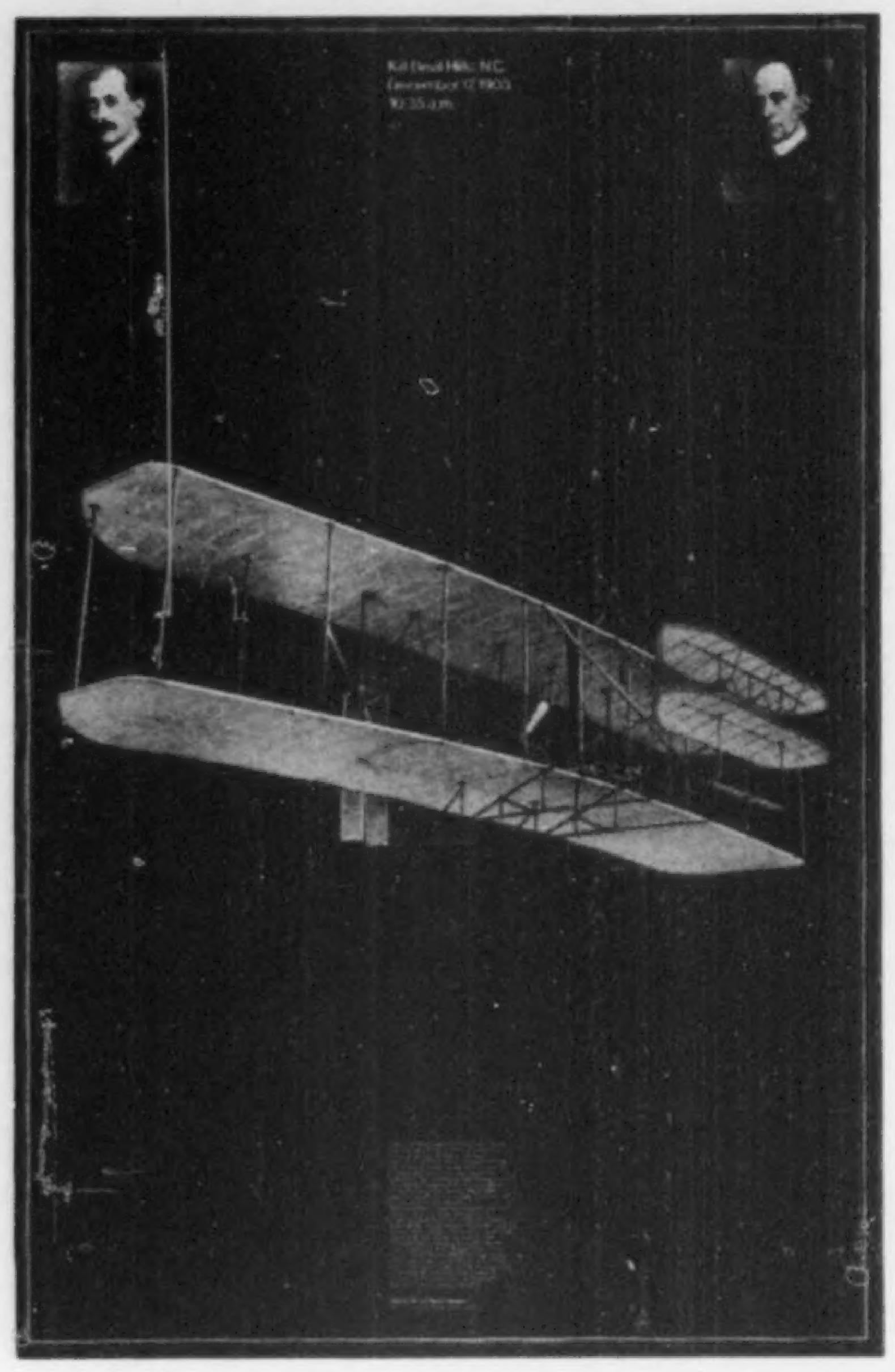
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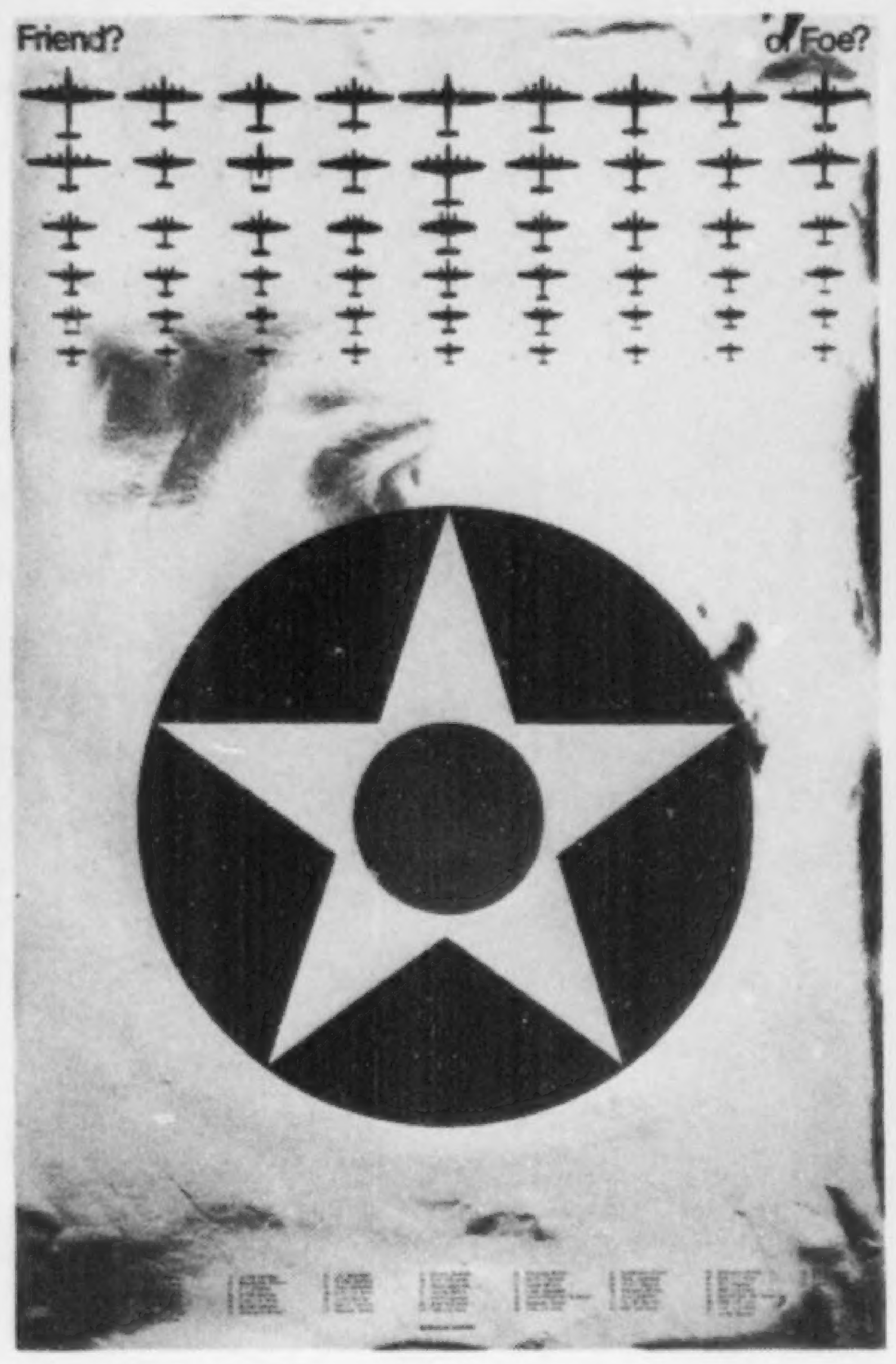
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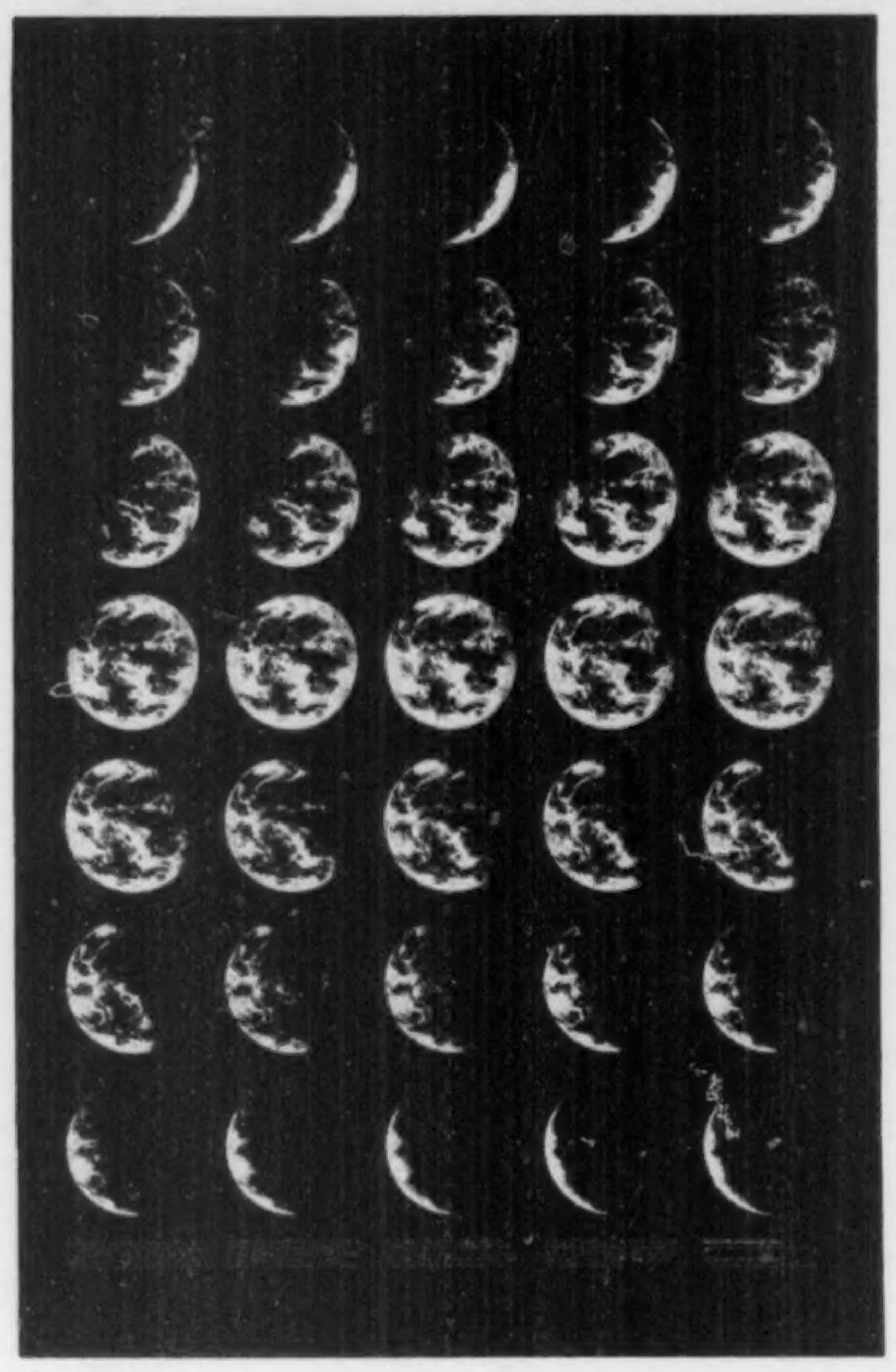
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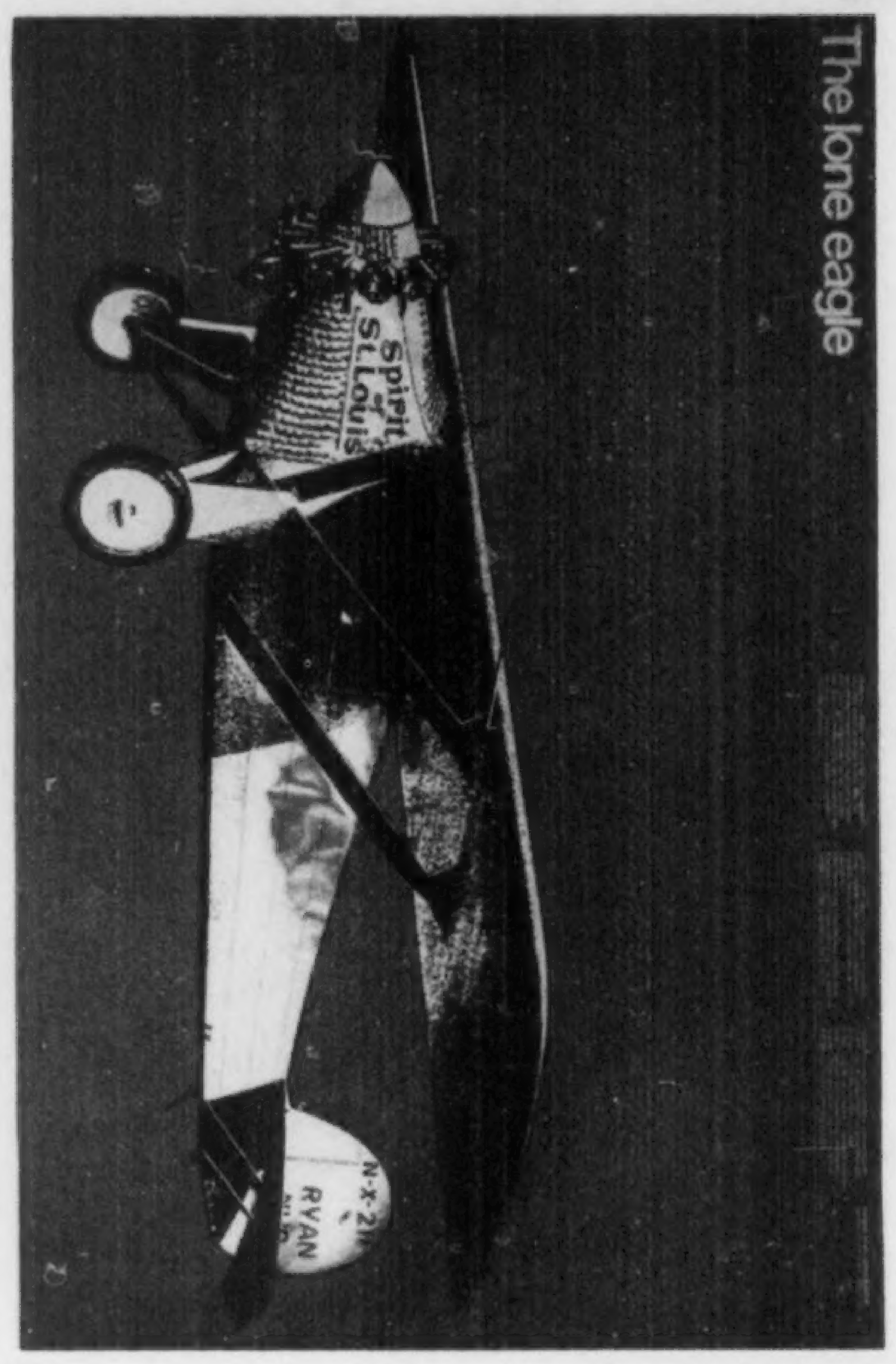

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C. *Day and Night* Earth phase photographs taken by satellite 22,300 miles above the Earth show the pattern of daylight and nightfall. Blue and white photographs, black background.
D. *The Lone Eagle* Lindberg was the first to fly solo non-stop across the Atlantic. He made this historic flight in 1927 in his Ryan NYP single-engine plane, *The Spirit of St. Louis.* Silver plane with black markings, red background, white type.

Not shown:
E. *Pioneers of Flight* The people pictured made significant contributions to aeronautics and astronautics. Photographic strips are silver, green, red, yellow, brown, and blue; white background, black type.
F. *The Stars Are In Us* Lagoon Nebula, photographed by Kitt Peak National Observatory. Light and dark shades of purple, white lettering.
G. *Flight and the Arts* Reproduction of *Sky Garden,* which is part of the Apollo Stoned Moon print series by Robert Rauschenberg (American, b. 1925). Full color.
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